HumRRO

Technical Report 91 June 1964

The Effects of Observer Location and Viewing Method on Target Detection With the 18-Inch Tank-Mounted Searchlight

by

Nicholas B. Louis

U.S. Army Armor Human Research Unit
Fort Knox, Kentucky

Under the Technical Supervision of

The George Washington University
HUMAN RESOURCES RESEARCH OFFICE
operating under contract with
THE DEPARTMENT OF THE ARMY

HEADQUARTERS
DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF RESEARCH AND DEVELOPMENT
WASHINGTON, D.C. 20310

CRD/J

SUBJECT: The Effects of Observer Location and Viewing Method on Target Detection with the 18-Inch Tank-Mounted Searchlight

TO: COMMANDER
DEFENSE DOCUMENTATION CENTER
ARLINGTON HALL STATION
ARLINGTON, VIRGINIA 22314

1. The attached report is for your information and retention.

2. This report concerns a study made to investigate the problem suggested by the title.

3. Results of the research indicate that observers who were displaced from the searchlight source made significantly more detections than observers in the carrier tank. Binoculars were a more effective viewing instrument than the tank range finder, the periscope, or unaided vision. For the first minute of search the unaided eye was as effective as binocular-aided search.

4. This report is considered applicable and should be of interest to all agencies which are concerned with the operations of the combined arms team.

5. It is desired that interested agencies review this report with a view toward making recommendations based on local experience in the area of this study. Recommendations should be processed through appropriate headquarters.

FOR THE CHIEF OF RESEARCH AND DEVELOPMENT:

1 Incl
as

WILLIAM G. SULLIVAN
Colonel, GS
Chief, Human Factors and Operations
Research Division

AD________________________Div. 6, 16, 22

Human Resources Research Office, George Washington U., Alexandria, Va. 22314
THE EFFECTS OF OBSERVER LOCATION AND VIEWING METHOD ON TARGET DETECTION WITH THE 18-INCH TANK-MOUNTED SEARCHLIGHT, by Nicholas B. Louis, June 64, 52 pp. incl. illus, tables, 12 refs. (Technical Report 91)
(Contract DA 44-188-ARO-2) (DA Proj 2J024701A712) Unclassified Report

An experiment was designed to determine the effects on target detection of observer location and method of viewing in relation to several types of targets at selected distances. Data were collected from 336 observers stationed at the searchlight source and at various distances up to 160 yards from the light, along a line at approximately a right angle to the axis of the beam. Using the tank range finder, periscope, binoculars, or unaided vision, observers tried to detect and identify a jeep, tank, and APC at each of four distances. Observers farther away from the light source detected and identified more targets than observers close to the searchlight. Binoculars and, for the first 30 seconds, unaided vision were more effective than the range finder or periscope in detecting and identifying targets.

UNCLASSIFIED

1. Detection and tracking—target discrimination
2. Lighting equipment—searchlights
3. Vehicles—armored vehicles

I. Title: ARMORNITE V
II. Louis, Nicholas B.
III. U.S. Army Armor Human Research Unit, Fort Knox, Ky.
IV. Contract DA 44-188-ARO-2

AD________________________Div. 6, 16, 22

Human Resources Research Office, George Washington U., Alexandria, Va. 22314
THE EFFECTS OF OBSERVER LOCATION AND VIEWING METHOD ON TARGET DETECTION WITH THE 18-INCH TANK-MOUNTED SEARCHLIGHT, by Nicholas B. Louis, June 64, 52 pp. incl. illus, tables, 12 refs. (Technical Report 91)
(Contract DA 44-188-ARO-2) (DA Proj 2J024701A712) Unclassified Report

An experiment was designed to determine the effects on target detection of observer location and method of viewing in relation to several types of targets at selected distances. Data were collected from 336 observers stationed at the searchlight source and at various distances up to 160 yards from the light, along a line at approximately a right angle to the axis of the beam. Using the tank range finder, periscope, binoculars, or unaided vision, observers tried to detect and identify a jeep, tank, and APC at each of four distances. Observers farther away from the light source detected and identified more targets than observers close to the searchlight. Binoculars and, for the first 30 seconds, unaided vision were more effective than the range finder or periscope in detecting and identifying targets.

UNCLASSIFIED

1. Detection and tracking—target discrimination
2. Lighting equipment—searchlights
3. Vehicles—armored vehicles

I. Title: ARMORNITE V
II. Louis, Nicholas B.
III. U.S. Army Armor Human Research Unit, Fort Knox, Ky.
IV. Contract DA 44-188-ARO-2

AD________________________Div. 6, 16, 22

Human Resources Research Office, George Washington U., Alexandria, Va. 22314
THE EFFECTS OF OBSERVER LOCATION AND VIEWING METHOD ON TARGET DETECTION WITH THE 18-INCH TANK-MOUNTED SEARCHLIGHT, by Nicholas B. Louis, June 64, 52 pp. incl. illus, tables, 12 refs. (Technical Report 91)
(Contract DA 44-188-ARO-2) (DA Proj 2J024701A712) Unclassified Report

An experiment was designed to determine the effects on target detection of observer location and method of viewing in relation to several types of targets at selected distances. Data were collected from 336 observers stationed at the searchlight source and at various distances up to 160 yards from the light, along a line at approximately a right angle to the axis of the beam. Using the tank range finder, periscope, binoculars, or unaided vision, observers tried to detect and identify a jeep, tank, and APC at each of four distances. Observers farther away from the light source detected and identified more targets than observers close to the searchlight. Binoculars and, for the first 30 seconds, unaided vision were more effective than the range finder or periscope in detecting and identifying targets.

UNCLASSIFIED

1. Detection and tracking—target discrimination
2. Lighting equipment—searchlights
3. Vehicles—armored vehicles

I. Title: ARMORNITE V
II. Louis, Nicholas B.
III. U.S. Army Armor Human Research Unit, Fort Knox, Ky.
IV. Contract DA 44-188-ARO-2

AD________________________Div. 6, 16, 22

Human Resources Research Office, George Washington U., Alexandria, Va. 22314
THE EFFECTS OF OBSERVER LOCATION AND VIEWING METHOD ON TARGET DETECTION WITH THE 18-INCH TANK-MOUNTED SEARCHLIGHT, by Nicholas B. Louis, June 64, 52 pp. incl. illus, tables, 12 refs. (Technical Report 91)
(Contract DA 44-188-ARO-2) (DA Proj 2J024701A712) Unclassified Report

An experiment was designed to determine the effects on target detection of observer location and method of viewing in relation to several types of targets at selected distances. Data were collected from 336 observers stationed at the searchlight source and at various distances up to 160 yards from the light, along a line at approximately a right angle to the axis of the beam. Using the tank range finder, periscope, binoculars, or unaided vision, observers tried to detect and identify a jeep, tank, and APC at each of four distances. Observers farther away from the light source detected and identified more targets than observers close to the searchlight. Binoculars and, for the first 30 seconds, unaided vision were more effective than the range finder or periscope in detecting and identifying targets.

UNCLASSIFIED

1. Detection and tracking—target discrimination
2. Lighting equipment—searchlights
3. Vehicles—armored vehicles

I. Title: ARMORNITE V
II. Louis, Nicholas B.
III. U.S. Army Armor Human Research Unit, Fort Knox, Ky.
IV. Contract DA 44-188-ARO-2

The Effects of Observer Location and Viewing Method on Target Detection With the 18-Inch Tank-Mounted Searchlight

by

Nicholas B. Louis

Approved:

NORMAN WILLARD, Jr.
Director of Research
U.S. Army Armor Human Research Unit
Fort Knox, Kentucky

WALTER J. DAVIES
Lt. Col., Armor Chief
U.S. Army Armor Human Research Unit
Fort Knox, Kentucky

MEREDITH P. CRAWFORD
Director
Human Resources Research Office

The George Washington University
HUMAN RESOURCES RESEARCH OFFICE
operating under contract with
THE DEPARTMENT OF THE ARMY

Technical Report 91
June 1964

371
Copy
Task ARMORNITE V

The Human Resources Research Office is a nongovernmental agency of The George Washington University, operating under contract with the Department of the Army (DA 44-188-ARO-2). HumRRO's mission, outlined in AR 70-8, is to conduct research in the fields of training, motivation, and leadership.

Research is reported by HumRRO in publications of several types.

1. *Technical Reports* are prepared at the completion of a research Task or major portion thereof. They are designed specifically for a military audience and convey recommendations for Army action.

2. *Research Reports* may be prepared at any time during a Task. They are designed primarily for a research audience but may be of interest to a military audience. They report research findings of interest and value to the scientific community and do not recommend Army action.

3. *Research Memoranda* may be prepared at any time and need not be directly associated with a particular research Task. They report findings that may be of interest to a research or military audience or to both. They do not recommend Army action.

4. *Consulting Reports* are prepared upon completion of consulting action requested under HumRRO's Technical Advisory Services. They are intended for a specific military audience and usually contain guidelines for implementation.

5. *Research Bulletins* are prepared as nontechnical summaries of one or more research Tasks or as reports of other HumRRO activities. They are intended primarily for a military audience and do not present recommendations for Army action. Their distribution usually includes agencies and individuals conducting research, and the general public.

Technical Reports, Research Reports, and Research Bulletins may be requested from the Director's Office, which also issues a complete bibliography. Other publications may be obtained from the Director of Research of the originating Unit or Division.

Published
June 1964
by
The George Washington University
HUMAN RESOURCES RESEARCH OFFICE
300 North Washington Street
Alexandria, Virginia 22314

Distributed under the authority of the
Chief of Research and Development
Department of the Army
Washington, D.C. 20310

CREDITS

Dr. Howard H. McFann was Director of Research, and Col. William L. Boylston was the Military Chief during conduct of the research.

CONTENTS

Figures

Tables

SUMMARY AND RECOMMENDATIONS

MILITARY PROBLEM

Increasing emphasis in modern warfare on fighting at night makes it essential to obtain basic information that will be useful in conducting armor training under conditions of limited visibility. Since searchlights have been added to the tank weapon system, the probability that the carrier tank will be knocked out by the enemy during the interval when the searchlight is turned on has been determined for several periods of illumination (Kraemer, 1959). Similarly, it was considered essential to determine the probabilities of detecting enemy targets with the searchlight turned on for several periods of time while the carrier tank is facing enemy armor or antitank fire.

RESEARCH PROBLEM

Among the many factors that govern target detection at night, operational factors such as viewing method, techniques of observation, and duration of illumination are more easily manipulated than either atmospheric conditions or observer characteristics. Detection depends, fundamentally, on the amount of contrast between the target and its surround, transmitted to an observer as reflected light; hence, it is important to obtain optimum contrast for target observation. At night especially, the amount of contrast, and consequently the probability of detection, may be expected to vary greatly with such conditions as observer location and method of viewing, as well as with type and distance of target.

An experiment was designed to determine the effects of observer location and viewing method on the probability of detecting and identifying selected types of combat targets at selected distances within specific intervals of time.

RESEARCH METHOD

Observers were stationed at the searchlight source and at 10, 20, 40, 80, and 160 yards from the light along a line at approximately a right angle to the axis of the beam. On each run of the experiment there were 24 observers, four at each of the six locations, using, respectively, the tank range finder, the periscope, binoculars, and unaided vision. Each observer had 16 trials. On 12 trials he tried to detect and identify three types of combat target—jeep, tank, and armored personnel carrier (APC)—at each of four distances (655, 780, 900, and 1055 yd.); on 4 additional trials no target was shown.

During each trial the searchlight was turned on for two minutes. The observer pressed a button when he detected a target, all the detection responses being electrically recorded and timed. Observers tried to verify their detection responses by laying the tank gun or pointing an aiming circle, depending on the viewing method they were using; these verifications and the target identification were recorded by a scorer.

The experiment was run, beginning at least an hour after sunset, on each of 16 nights. Data were compiled for 336 observers.

SUMMARY AND RECOMMENDATIONS

RESULTS

When detection probability, identification probability, and time scores had been calculated, the results were as follows:

1. For all time intervals checked, observers who were in positions to the side of the searchlight source made significantly more detections than observers at the searchlight.

2. For all time intervals, binoculars—and, for the first 30 seconds, unaided vision—were significantly more effective in *detecting* targets than were the range finder and the periscope. After one minute, binoculars were reliably more effective than unaided vision. The range finder was always somewhat more effective than the periscope, although not significantly so.

3. Binoculars were the most effective method of *identifying* targets, with the best performance occurring at observer locations 80 and 160 yards from the searchlight. Identification performance at the source was significantly inferior to identification performances at 80 and 160 yards, but was not significantly different from performances at 10, 20, and 40 yards from the light source.

4. As expected, the probability of detection and identification fell off sharply as target distance increased, and the probability of identifying larger targets (tank and APC) was greater than for the jeep. Data were compiled on the probabilities of detection and identification at various ranges.

CONCLUSIONS AND IMPLICATIONS

1. When the tank-mounted searchlight is used in armor night operations, observers who are stationed away from the searchlight will detect and identify more targets than observers in the carrier tank. The relative effectiveness of observers in various positions will vary with the tactical situation, and with conditions of atmosphere and terrain.

2. In general, binoculars are the most effective method of detecting and identifying targets under searchlight illumination, with unaided vision about as effective as binoculars during the first minute of search.

3. In the first 30 seconds of search, there is a 50% probability that an observer using binoculars will detect a target at 900 yards for a tank or APC, and roughly 750 yards for a jeep.

4. In assessing the comparative effectiveness of the viewing methods, consideration must be given to the amount of transition time required for laying the gun on target with each type of viewing device. In estimating possible performance during searchlight illumination, transition time must be added to detection time before accurate fire is possible. To determine which procedure requires less time, a comparison would have to be made between (a) the time needed to detect targets using binoculars or unaided vision and to lay the gun on target using the range finder, and (b) the time required to use the range finder for both detection and gun laying.

RECOMMENDATIONS

It is recommended that:

1. When the tank-mounted searchlight is used for target detection, observers be located to the side of the carrier tank. Their positions could be as far out as 160 yards, the exact location depending on the tactical situation and on conditions of atmosphere and terrain.

2. The information on effective procedures for use of the tank-mounted searchlight to detect targets, and the capabilities and limitations in such use be made available in appropriate training manuals and training circulars.[1]

[1]This information has been incorporated in FM 17-12 (Dept. of the Army, 1961), Par 157 b, "Techniques of Night Firing," (6) (d), pp. 178-179.

DESCRIPTION OF THE RESEARCH

The Effects of Observer Location and Viewing Method on Target Detection With the 18-Inch Tank-Mounted Searchlight

INTRODUCTION

The 18-inch tank-mounted searchlight has been added to armor equipment to facilitate armor night operations, chiefly by illuminating enemy positions. Because the tank that carries the searchlight becomes an excellent target at night, the user may be in danger during the period of illumination. In a previous study at the U.S. Army Armor Human Research Unit it was determined how long it might take the enemy to hit a carrier tank after its searchlight had been turned on (Kraemer, 1959). An associated problem is to determine how long it would take, using a searchlight for illumination under optimum conditions, to detect an enemy target. It is essential to obtain this basic information so that it can be applied to the greatest advantage of friendly forces, in a variety of tactical situations, and included in the armor night training program as appropriate.

Many factors affect the ability of the observer to see a specific combat target. These factors are of three kinds: characteristics of the observer, aspects of the physical environment that affect visibility, and methods of operation.[1] Observer variables may be physiological—individual differences in vision, the nervous system, and level of fatigue—or they may be psychological, based on motivation, training, and experience. Environmental factors include atmospheric conditions, ambient illumination, target characteristics, surround characteristics, and, at night, searchlight properties. Operational factors include optical aids, techniques of observation, and, at night, the positioning and movement of the searchlight and the duration of its light. This study deals primarily with operational factors at night.

Conditions of the environment and methods of operation affect the apparent contrast between the target and its surroundings and, hence, its visibility. Target detection depends, fundamentally, on contrast between the target and its background, transmitted to the observer as reflected light. When a searchlight is used during night operations, light reflected toward the observer by particles in the atmosphere (backscatter) may serve to reduce the amount of contrast between target and background. An observer in or very near the carrier tank looks down the beam for almost the full distance to the target and is therefore exposed to much backscatter. As he moves away from the light (at right angles to the beam), he looks through less and less backscatter. However, in practice, the increasing distance to the target and possible interference with the sight path by trees, bushes, or rolling terrain limit the distance he should go from the beam. This holds true

[1]A detailed discussion of these factors may be found in Blackwell, Duntly, and Kincaid (1953); Gordon (1957); Granath and Hulbert (1929); Jenkins and White (1957); Middleton (1952); and Wulfeck, Weisz, and Raben (1958).

regardless of the viewing method he is using—range finder, telescope, periscope, hand-held binoculars, or unaided vision.

STATEMENT OF PURPOSE

The purpose of this study was to determine specific effects of the observer's location and viewing method on detecting and identifying targets at night, using the searchlight as a means of illuminating the target. These effects were determined for selected target distances and for selected types of targets.

METHOD

Design

A factorial design was used involving six observer locations, four viewing methods, four types of targets, and four target distances. On each of the 16 nights of the experiment, 24 observers (four at each of six locations) ran through a set of 16 trials (each target at each distance). Target detection, detection time, and target identification were recorded for each observer on each trial.[2]

Observer Location. The observers were stationed at various distances from the searchlight source, along a line at approximately a right angle to the axis of the searchlight beam. They were located at the light source, and 10, 20, 40, 80, and 160 yards from the searchlight. These locations were chosen to include most of the range over which backscatter from the searchlight beam is a significant problem.

Viewing Methods. The observers used unaided vision, hand-held binoculars, a tank gunner's periscope, or a tank range finder as their viewing method. Observers using the first two methods were on platforms during the trials; those using the last two methods were in the tank commander's station in tanks. The different viewing methods permitted comparison of the effects of varying fields of vision and degrees of magnification.

Types of Targets. Three types of actual targets were used: the M48A2 tank, the M58 armored personnel carrier (APC), and the M41 1/4-ton truck (jeep); a no-target condition served as control. These vehicles were selected because they are commonly used in battlefield situations and because they vary in size and configuration, both important considerations in tests of target detectability. The tank and the APC are about the same size (60 sq. ft.) viewed from the front; the jeep is about one-fifth as large. The jeep and the APC have a similar rectangular shape, in contrast to the tank's irregular outline.

Target Distance. The three vehicles were shown 655, 780, 900, and 1055 yards from the searchlight; these distances provided variations in detectability at ranges close enough for most subjects to have at least some success in detecting targets.

[2]Problems in administering the trials during the first two nights made it advisable to discard the data collected for those nights.

Sequence. On each of the 16 trials in a single series, observers in all locations tried to detect a target while the searchlight was turned on for two minutes. On four of the trials there was no target; on the remaining 12 trials a vehicle was shown, each of the three vehicles once at each of the four distances. The sequences followed in the 16-trial series of observations on each night of the experiment are shown in Appendix A.

The physical arrangements provided for only 12 observers at a time, one in a tank and one on a platform at each of the six observer locations. It was therefore necessary to run two identical sequences of trials on each night of the experiment, using 12 observers in each sequence.

Subjects

A total of 384 subjects were tested in the experiment, which was conducted during the summer of 1958. Data were analyzed for 336 (those run on nights 3 to 16), of whom 330 were soldiers at Fort Knox and 6 were civilian employees of the Armor Unit. None of the subjects had had experience in target detection at night.

The subjects were screened for certain visual defects that might affect their performance on any one of the viewing methods, but otherwise were randomly assigned to the various experimental conditions. In the unaided vision method, observers were allowed to use whatever corrective lenses they possessed, except that no subject was assigned to this group whose uncorrected vision in either eye was less than 20/50. On the basis of a screening test run on a Bausch & Lomb Ortho-Rater, no observer who had severe lateral or vertical phoria was assigned to a binocular viewing task.

Procedure

Each night, data collection was begun at least an hour after sundown. After the first 12 observers were in position, they received instructions on how to report the targets they detected (see Appendix B). They were told to make every effort to detect a target, but were also informed that a vehicle might or might not actually be presented on any given trial. They were then given a four-minute practice trial during which a tank was presented at 655 yards.

In the ensuing series, each trial lasted the two minutes the searchlight was turned on. This provided adequate time for the subject to detect and report a target and complete the lay of the tank or aiming circle reticle, and for the scorer to check the lay.

After each trial, the next vehicle target was moved into position under blackout driving conditions. All target-vehicle engines and all auxiliary generators in the observer tanks were operated continously to mask auditory cues to target positioning between trials.

Five seconds before the searchlight was turned on, a warning was given. A trial then began with the appearance of the beam. The observer signaled his detection of the target by pressing a button that electrically recorded and timed his detection responses. He reported his identification of the type of target vehicle he detected, and this

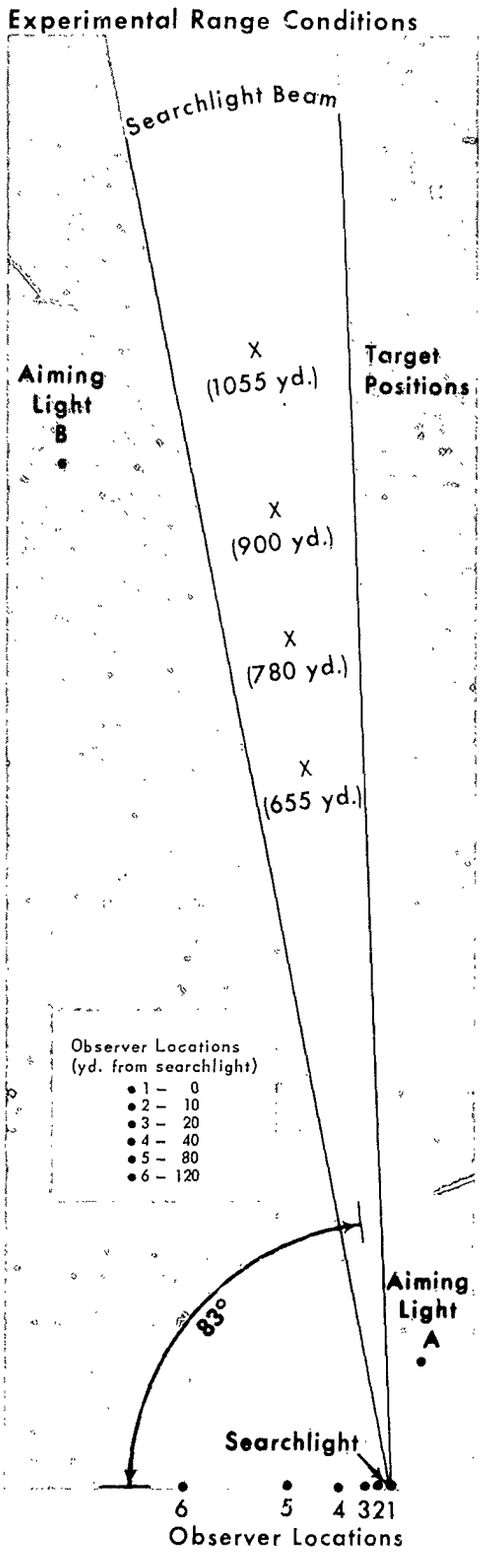

Figure 1

identification was recorded by a scorer stationed with each observer. Then, to verify detections, observers using binoculars or unaided vision tried to align the telescope of an aiming circle on target, and observers using the range finder or the periscope tried to lay the sight on the target; after the lay, the scorer recorded the azimuth readings.

Range Site and Equipment

The site was on very level terrain, sufficiently clear of obstructions to render all targets clearly visible from all observer locations, but with no targets "skylined."

Figure 1 is a diagram of the experimental area. A tank with a platform beside it was stationed at each observer location indicated by numbers on the diagram. The searchlight was mounted beside Observer Location 1, on a separate stand. The searchlight was as high as if it were mounted on a tank with the gun tube depressed for use.

Observer Tanks. Observers who used the range finder or the periscope were positioned in tanks with the crew hatches closed. Six M48A2 medium tanks were used; they were rotated among the six locations between nights of data collection, to reduce differences that might be due to varying speeds of turret operation. At the beginning of each sequence of trials, the azimuth indicators were zeroed on an aiming light (see Fig. 1).

Observer Platforms. Observers who used binoculars or unaided vision were stationed on the platforms. The platforms were constructed so that the observer stood at the same level above ground as a man standing in the tank commander's position with head and shoulders out of the hatch.

Searchlight. The mounted 18-inch tank searchlight[3] used in the study was equipped with a 2500-watt lamp.[4] It was aimed so that the center of the beam illuminated all the target positions. The center of the beam made an angle of about 83° with the line from the light source to the farthest observer location (range limitations precluded use of a 90° angle). The position of the light and its beam was not changed during the course of the experiment. The light was powered by a tank auxiliary engine generator.

Viewing and Aiming Devices. The three viewing devices used were:

(1) M17A1 Binocular, 7-power, 7° 16' field of view
(2) M20 Periscope, 6-power, 8° field of view
(3) M13 Range Finder, 10-power, 4° field of view

Subjects who used the periscope or the range finder aimed at the targets by rotating the tank turret. Those who used unaided vision or binoculars aimed with the 2-power telescope attached to the M2 aiming circle. This telescope has a 10° field of view.

Detection-Time Recorder. As soon as he detected a target, the observer operated a switch, closing a circuit that actuated a recording pen on an Esterline-Angus recorder. Thus a permanent record was made of each observer's detection time on each trial.

Atmospheric Conditions

For each night of data collection, atmospheric conditions and ambient illumination were documented and target contrast values were also determined. Since all experimental conditions were tested in the same session, none of these factors was prejudicial to any experimental condition.[5]

ANALYSIS

Probability of Detection

As stated earlier, observers were required to align a reticle on a detected target to provide verification of detection responses. However, the error allowed in aligning the reticle was arbitrarily limited to the area presented by the target; hence, the likelihood of verifying the detection by accurate aiming depended on target size and target distance. An observer who detected a target, and even identified it correctly, might not aim accurately enough to meet the criterion for verifying his detection response.

An observer, therefore, could make two kinds of detections, verified and unverified, and among the unverified detections there were, no doubt, some that were true and some on which the observer had guessed. If his "probability of detection" were to be based upon all

[3]Strong Electric Corp., Toledo, Ohio (Model 9800-1-A).

[4]General Electric Co., Lamp Division, Cleveland, Ohio (Model T-30, 24-29v.).

[5]Records of atmospheric conditions, ambient illumination, and target contrast may be obtained from the Armor Unit on request.

his detections, both verified and unverified, it would be too high if any of his unverified detections were guesses; if it were to be based on his verified detections alone, it would be too low if he had any unverified but correct detections. An attempt was made to steer between these two extremes in calculating each observer's probability of detection, by including all his verified detections and a proportion of his unverified detections based on his performance on the four blank (no target) trials in the series of 16 trials.

For example, if on three of the four blank trials he reported no target and on one he reported a target, thus showing that he was guessing, this proportion was used in scoring on trials where there were targets: 75% of his unverified detections were included and 25% omitted in computing his probability of detection for the series. If he reported a target on each of the four blank trials, none of his unverified detections were included in the computations.

Probability of detection (P_d) was therefore defined as follows:

$$\frac{\text{(Number of verified detections)} + \text{(Number of unverified detections left after correcting for guessing rate)}}{\text{(Number of targets shown)}}$$

This relationship is formally expressed as:

$$P_d = \frac{D_v + (D_r - D_v)\left(\frac{4 - N_f}{4}\right)}{12}$$

when D_v is number of verified detections, D_r is number of reported detections, and N_f is number of false detections on blank trials.

Probability of Identification

Probability of identification was defined as:

$$\frac{\text{(Number of correct identifications)} - \text{(Number of identifications presumed to be guessed)}}{\text{(Number of targets presented)}}$$

that is: $P_i = \frac{N_i}{N_t}$

N_i being the number of correct identifications less the number presumed to be guessed.

The correction for guessing was based on the proportion of false identifications made by the observers during the four blank trials. These false identifications were totaled by target type across groups of subjects; 24 totals were computed for each vehicle, one per viewing device at each target location. After these totals were computed, the data for the three vehicles were combined.

For example, the subjects who used binoculars at Observer Location 4 correctly identified 37 of the 56 tank targets; they made three reports of seeing a tank during the 56 blank trials. They correctly identified 23 of the 56 APC targets, and did not report seeing an APC during the blank trials; they correctly identified 16 of the 56

jeep targets, and made one report of seeing a jeep during the blank trials. Therefore:

$$37 - \left(\frac{3}{56} \times 37\right) = 35.02 \text{ identifications of tank targets}$$

$$23 - \left(\frac{0}{56} \times 23\right) = 23.00 \text{ identifications of APC targets}$$

$$16 - \left(\frac{1}{56} \times 16\right) = \frac{15.71}{73.73} \text{ identifications of jeep targets}$$

The total is 73.73 identifications out of 168 targets, or a $\underline{P}_i$ of $\frac{73.73}{168}$, or 0.44.

Detection Time

This measure was defined as the time elapsed between the onset of illumination and the detection of the target by the observer, and was recorded for every trial for every observer.

RESULTS

The effect of observer location with respect to a carrier tank and the effect of viewing method on (1) number of targets detected, (2) number correctly identified, and (3) time required for detection, are considered the most important results of the experiment. The effects of target type and of target distance on these three measurements are also of interest.

Target Detection

The probability of detecting targets ($\underline{P}_d$) from the six observer locations, by means of the four viewing methods for selected times is shown in Table 1 and depicted in Figures 2 and 3. Detailed information on total detections under the various experimental conditions, and the proportions of false detections used in calculating probabilities, are given in Appendix C, Table C-1. Analyses of variance and $\underline{t}$ tests were used to test the significance of differences between the numbers of targets detected, after various cumulative intervals of time, by observers at the six locations and with the four viewing devices. The means and the results of these analyses are shown in Appendix Tables C-2 and C-3.

During all intervals of time for which the data were summarized, observers at any location to the side of the searchlight made significantly more detections than observers at the searchlight. The only significant difference between numbers of detections at the other locations was that between 40 and 80 yards after an interval of 20 seconds; this was believed to be a chance difference rather than a real one.

For all intervals of viewing time tested, the number of detections made by observers using different viewing methods differed significantly. Throughout the experiment, binoculars were significantly more effective than the tank viewing devices (periscope and range finder) and, through the first 30 seconds, so was unaided vision. Only after 60 seconds of viewing did observers using binoculars accumulate enough detections to be reliably ahead of those using unaided vision.

Table 1[a]

Probability of Detecting Targets

(Observer N = 14)

Observer Location	Yards From Searchlight	Time (sec.)	Viewing Method				
			Unaided Vision	Binoculars	Periscope	Range Finder	Average for All Methods
1	0	10	.14	.11	.05	.02	.08
		15	.22	.17	.14	.05	.14
		20	.23	.25	.19	.09	.19
		30	.26	.33	.25	.17	.25
		60	.35	.44	.37	.39	.38
		120	.40	.51	.45	.48	.46
2	10	10	.23	.22	.06	.08	.15
		15	.31	.36	.12	.14	.23
		20	.35	.41	.21	.19	.29
		30	.39	.53	.36	.28	.39
		60	.44	.61	.55	.49	.52
		120	.47	.65	.62	.55	.57
3	20	10	.29	.19	.06	.08	.15
		15	.34	.32	.12	.15	.23
		20	.37	.42	.21	.23	.31
		30	.44	.49	.31	.37	.40
		60	.48	.59	.43	.53	.51
		120	.52	.64	.50	.64	.58
4	40	10	.21	.27	.01	.01	.13
		15	.28	.36	.06	.13	.21
		20	.35	.42	.12	.17	.27
		30	.41	.54	.26	.27	.37
		60	.49	.69	.46	.44	.52
		120	.50	.76	.53	.54	.58
5	80	10	.40	.24	.02	.05	.18
		15	.47	.39	.10	.13	.27
		20	.54	.48	.17	.19	.34
		30	.59	.58	.25	.28	.42
		60	.67	.69	.38	.47	.55
		120	.72	.71	.50	.61	.64
6	160	10	.33	.17	.02	.01	.13
		15	.36	.32	.08	.13	.22
		20	.41	.40	.13	.21	.29
		30	.43	.51	.22	.30	.37
		60	.51	.63	.40	.51	.51
		120	.58	.73	.56	.64	.63
Average for All Locations		10	.27	.20	.04	.04	
		15	.33	.32	.10	.12	
		20	.37	.40	.17	.18	
		30	.42	.50	.27	.28	
		60	.49	.61	.43	.47	
		120	.53	.67	.53	.58	

[a]See also Table C-3.

Probability of Detection for Each Observer Location, as a Function of Viewing Time

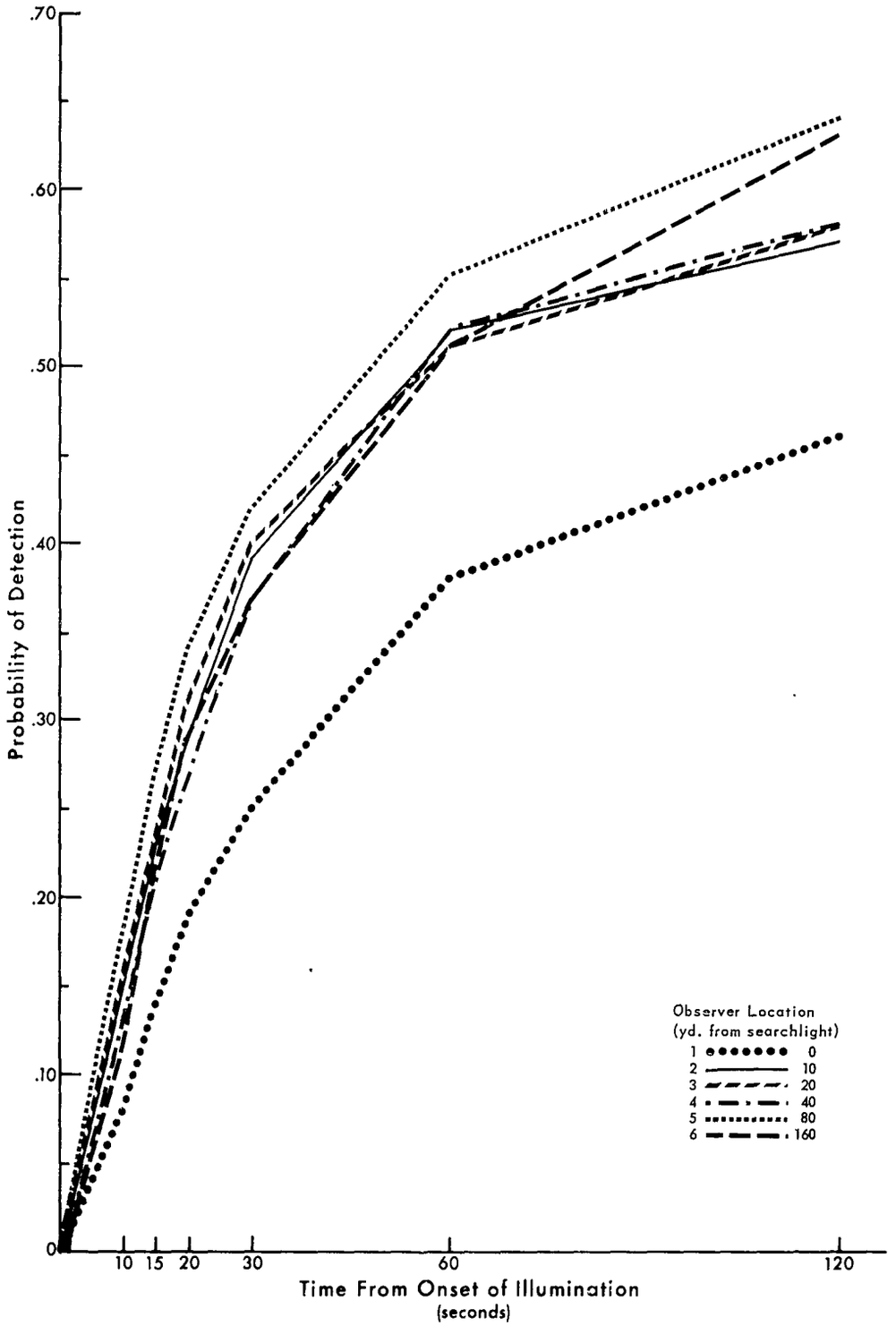

Figure 2

Probability of Detection for Each Viewing Method, as a Function of Viewing Time

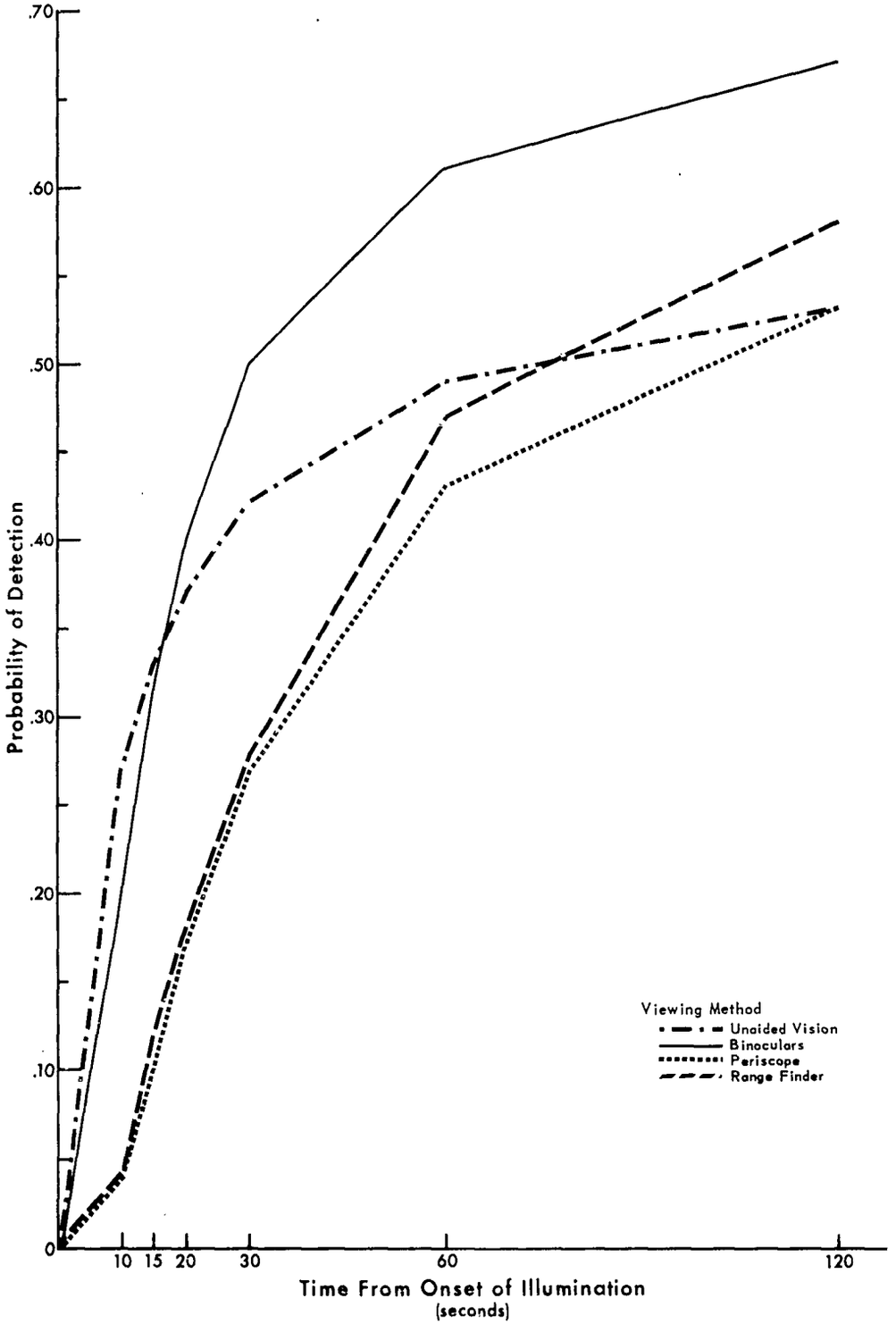

Figure 3

The two tank devices did not differ significantly in effectiveness at any time, although the range finder was always slightly more effective than the periscope.

Target Identification

The probability of identifying targets with each viewing device at each observer location is shown in Table 2. A tabulation of correct identifications for each target type and the rate of guessing used in calculating probabilities are presented in Appendix D.

Table 2

Probability of Identifying Targets

Observer Location	Yards From Searchlight	Viewing Method				
		Unaided Vision	Binoculars	Periscope	Range Finder	Average for All Methods[a]
1	0	.20	.32	.25	.30	.27
2	10	.26	.42	.29	.28	.31
3	20	.26	.43	.27	.29	.31
4	40	.25	.44	.27	.30	.32
5	80	.37	.50	.22	.38	.37
6	160	.36	.52	.38	.48	.44
Average for all locations[b]		.28	.44	.28	.34	

[a]A difference of 6.1 for observer location is significant at the .05 level.
[b]A difference of 5.0 for viewing method is significant at the .05 level.

Gross tests of differences in numbers of identifications made at the various observer locations showed that binoculars were the most effective viewing method, and that they were used most effectively at 80 and 160 yards from the searchlight.

When the data for the six observer locations were averaged across viewing methods, tests of the mean differences showed that performance at the searchlight was significantly less effective than performances at 80 and 160 yards, but not different from performances at 10, 20, and 40 yards from the searchlight.

Target Distance and Type

Although it is obvious that a nearby vehicle is easier to detect than a more distant one and that the size of a tank or personnel carrier makes them easier to detect than a jeep, quantitative information as to the specific effects of target type and distance has not previously been available. The data collected in the present study can be analyzed to provide information of this nature.[6]

[6]Relationships between target distance and observer location, target type, and viewing method, for both detection and identification of targets, are illustrated in Appendix E.

For example, just how far away must a tank target be before probability of detection drops below .50? In Table 3 this question is answered in terms of the detection and identification of the three vehicle types at the four target distances used in the study, for observers using binoculars, and stationed 80 yards from the searchlight. This is the experimental condition that, in general, showed the best detection and identification performance. The probability of detecting targets dropped from about .90 to about .70 as distance increased from 655 to 900 yards. However, with a distance increase of another 155 yards (to 1055), the detection probability dropped below .50. Accuracy of target identification fell off rapidly as distance increased, from a probability of almost .80 at 655 yards to about .50 at 780 yards and less than .30 at 1055 yards.

Table 3

Performance on Targets Viewed From 80-Yard Position by Observers Using Binoculars

Target Type	Target Distance (yd.)			
	655	780	900	1055
Probability of Detection				
Tank	.87	.89	.74	.54
APC	.96	.83	.81	.60
Jeep	.90	.66	.59	.32
Probability of Identification				
Tank	.84	.72	.46	.39
APC	.84	.56	.49	.21
Jeep	.70	.28	.35	.21

The data on detectability of targets indicated not only that the two larger targets—tank and APC—were more readily detected than the jeep, but also that the APC was somewhat more readily detected than the tank. However, tanks were identified correctly more often than either of the other target types.

DISCUSSION

Observer Location

According to the results, the probability of detecting and identifying illuminated combat-type targets will be increased by placing the observer to the side of the searchlight beam. The most effective location would be determined by the situation with regard to terrain, atmospheric conditions, and other factors. If the searchlight is mounted on a tank, other tanks that contain observers and gunners should be deployed so that crewmen do not have to look directly down the searchlight beam.

Viewing Devices

Although a two-minute trial period was used for collecting and recording data in this experiment, previous research (Kraemer, 1959)

indicates that it would be unwise for a combat commander to keep a searchlight illuminated for this long a period. If 30 seconds is taken as a maximum duration of searchlight illumination in combat, results in the present study indicated that binoculars or unaided vision offered considerably greater probability of detection than did the range finder or periscope.

However, it must be noted that if either binoculars or unaided vision is used in detecting targets, some time will be needed for transition to tank optics before the gun can be laid on the detected target. Therefore, before any conclusions can be drawn about the over-all effectiveness of the various viewing methods, the combined time required to use binoculars for searching and the range finder for laying the gun must be compared with the time needed when the range finder is used both for searching and for laying the gun.

Target Distance

While probability of detection increases with the amount of time provided for observation, it appears that the distances at which there is a 50% probability of detecting a target within 30 seconds are considerably shorter than was previously believed. The estimates obtained in this study, using binoculars, are 900 yards for a tank, 900 yards for an APC, and roughly 750 yards for a jeep. If the target were camouflaged or partially concealed, or if accurate location of the target were required, these estimates might be much reduced.

Target Type

The results for both detection and identification reflect the differences in configuration, size, and familiarity of the targets. Viewed from the front, the two larger vehicles, tank and APC, are similar in area. However, the APC has a boxy silhouette that may make it more easily detectable than the tank, which is irregular in outline with rounded edges. Nevertheless, in the identification part of the test, tanks were more often correctly identified.

Identification may have been influenced by the fact that the average observer is more familiar with the tank than with the APC. The subjects more often identified detected targets as tanks than as other types of vehicles. On blank trials, also, when they thought they saw a target, they most often identified it as a tank. Of the false detections on blank trials, 43% were identified as tanks, 10% APCs, 19% jeeps, and 28% other types of targets—panels, 2 1/2-ton trucks, artillery.

Motivation

Since many of the targets were at visual threshold or near it, motivation of the observers is a factor that must be taken into consideration in interpreting the findings of this study. The urgency of combat was, of course, absent in the experimental situation. Observers might perform rather differently in combat, but there is no reason to assume that the various experimental conditions of this study were differentially affected by observer motivation.

BIBLIOGRAPHY
AND
APPENDICES

BIBLIOGRAPHY

Blackwell, H. Richard, Duntly, S.Q., and Kincaid, Wilfred M. "Characteristics of Tank-Mounted Searchlights for Detection of Ground Targets," *Minutes and Proceedings of the 31st Meetings of the Armed Forces–National Research Council Vision Committee, November 1952,* Armed Forces–NRC Vision Committee, Washington, March 1953, pp. 270-301.

Department of the Army. *Tank Gunnery,* FM 17-12, Washington, April 1961.

Gordon, Donald A. *A Survey of Human Factors in Military Night Operations (With Special Application to Armor)* (U.S. Army Armor Human Research Unit), Special Report 11, Human Resources Research Office, Alexandria, Va. (published in Washington, D.C.), November 1957.

Granath, L.P., and Hulbert, E.O. "The Absorption of Light by Fog," *Physical Rev.,* vol. 34, July 1929, pp. 140-144.

Hamilton, Charles E. *Model Simulator Studies of the Visibility of Military Targets at Night,* Subcontractor's Final Report, Project 2699-1-F, Vision Research Laboratories, Engineering Research Institute, University of Michigan, Ann Arbor, August 1958.

Jenkins, Francis A., and White, Harvey E. *Fundamentals of Optics,* McGraw-Hill, New York, 1957, pp. 446-508.

Kraemer, Alfred J. *The Effectiveness of 90mm Tank Gun Fire Against the 18-Inch Searchlight (U)* (U.S. Army Armor Human Research Unit), Technical Report 56, Human Resources Research Office, Alexandria, Va. (published in Washington, D.C.), June 1959 (CONFIDENTIAL).

Middleton, W.E. Knowles. *Vision Through the Atmosphere,* University of Toronto Press, Toronto, Canada, 1952.

Olson, Howard C., Goss, Albert E., and Voiers, William D. *Recognition of Vehicles by Observers Looking Into a Searchlight Beam* (U.S. Army Armor Human Research Unit), Technical Report 49, Human Resources Research Office, Alexandria, Va. (published in Washington, D.C.), July 1958.

Pritchard, B.S., and Blackwell, H. Richard. *Preliminary Studies of Visibility on the Highway in Fog,* Final Report, Project 2557-2-F, Vision Research Laboratories, Engineering Research Institute, University of Michigan, Ann Arbor, July 1957.

U.S. Army Armor School. *Tank-Mounted Searchlights in the Armored Division (U),* Research Report, Committee 26, The Armor School, Fort Knox, Ky., April 1953 (CONFIDENTIAL), Appendix II, pp. 86-88.

Wulfeck, Joseph W., Weisz, Alexander, and Raben, Margaret W. *Vision in Military Aviation,* WADC Technical Report 58-399, Wright Air Development Center, Wright-Patterson AFB, Ohio, November 1958.

Appendix A

TARGET AND DISTANCE SEQUENCE OF OBSERVATION TRIAL SERIES

Target and Distance Sequence of Observation Trial Series

Target { A—Medium Gun Tank; B—Armored Personnel Carrier; C—No Target; D—¼-ton Truck }

Target Distance { 1— 655 yd.; 2— 780 yd.; 3— 900 yd.; 4—1055 yd. }

Trial	Night and Replication															
	1[a]	2[a]	3	4	5	6	7[b]	8	9	10	11	12	13	14	15	16
I	D3	A4	C	B2	B4	C	A2	D1	A1	D2	B3	C	C	B1	D4	A3
II	A4	B2	C	D1	D2	C	B1	A3	D3	C	B4	A2	A1	B3	C	D4
III	C	C	A1	C	D4	D3	B2	A2	D2	C	A3	A4	B4	D1	B3	B1
IV	B2	D1	C	A3	C	A2	B3	D4	A4	C	D2	B1	D3	B4	A1	C
V	B4	D2	D4	C	D1	C	D3	C	B3	A3	B2	A1	B1	A4	A2	C
VI	C	C	D3	A2	C	A4	D1	B1	C	A1	D4	B2	D2	A3	B4	B3
VII	A2	B1	B2	B3	D3	D1	D4	B4	C	A4	A1	A3	C	C	C	D2
VIII	D1	A3	A2	D4	C	B1	B4	C	B2	C	C	B3	A4	D2	D3	A1
IX	A1	D3	D2	A4	B3	C	C	B2	C	B4	B1	C	D4	A2	A3	D1
X	D2	C	C	C	A3	A1	A4	C	B4	D4	D1	D3	B3	B2	B1	A2
XI	B3	B4	A3	D2	B2	D4	A1	C	B1	D1	A4	C	A2	D3	C	C
XII	C	A2	A4	B1	A1	B2	A3	B3	C	D3	C	D1	C	D4	D2	B4
XIII	C	A1	B4	D3	B1	D2	C	A4	D4	B3	A2	C	A3	C	D1	B2
XIV	B1	B3	D1	B4	A4	A3	C	D2	A2	B2	D3	B4	C	A1	C	C
XV	D4	C	B3	A1	A2	B4	C	D3	A3	B1	C	D2	D1	C	B2	A4
XVI	A3	D4	B1	C	C	B3	D2	A1	D1	A2	C	B4	B2	C	A4	D3

[a]Because of administrative problems, data from nights 1 and 2 were not used.
[b]Actually the sequence of night 6 was also used on night 7.

Appendix B

INSTRUCTIONS TO OBSERVERS

INSTRUCTIONS TO OBSERVERS

Instructions to Tank Observers

You are a forward observer for your unit under orders to report immediately every military vehicle which you detect within the searchlight beam. Because radio silence is in effect in this problem, you will report your detection of a vehicle by momentarily depressing the trigger of the control handle; then immediately proceed to lay the main gun on the center of the target, momentarily depressing the trigger again as soon as you finish laying. Tell the recorder what the target is and your estimation of its distance from you.

Your reticle is aimed on a small light; five seconds after this light is turned off, the searchlight will go on. Be prepared to begin searching immediately after the searchlight is turned on. You will have to rotate the turret to your left to find the target. Make every effort to detect; if you do not see a target immediately, do not stop looking until the light is turned off or until you have made a detection. Remember that there may or may not be a target, but if there is one, it is your duty to report it. Your score will be penalized if you make a false detection, and you will not score a point if you fail to detect.

Instructions to Platform Observers

You are a forward observer for your unit under orders to report immediately every military vehicle which you detect within the searchlight beam. Because radio silence is in effect in this problem, you will report your detection of a vehicle by momentarily depressing the switch on the binoculars; then go to the aiming circle and align the cross hairs in the telescope as accurately as you can on the center of the target. Tell the recorder what the target is and your estimation of its distance from you.

You will see a small light in front of you; five seconds after the light is turned off the searchlight will go on. Be prepared to begin searching immediately after the searchlight is turned on. Make every effort to detect; if you do not see a target immediately do not stop looking until the light is turned off or until you have made a detection. Remember that there may or may not be a target, but if there is one, it is your duty to report it. Your score will be penalized if you make a false detection, and you will not score a point if you fail to detect.

Appendix C

TARGET DETECTION DATA

Table C-1

Percentages of Targets Detected for Each Testing Condition[a] *(Observer N = 14)*

Observer Location	Yards From Searchlight	Viewing Method	Target Distance (yd.)																All Distances				False Detections on Blank Trials
			655				780				900				1055								
			Tank	APC	Jeep	Mean	Tank	APC	Jeep	Mean	Tank	APC	Jeep	Mean	Tank	APC	Jeep	Mean	Tank	APC	Jeep	Mean	
1	0	Unaided vision	93	93	86	90	50	79	36	55	36	36	36	36	43	14	29	29	55	55	46	52	23
		Binoculars	93	100	86	93	71	79	57	69	43	36	50	43	29	36	14	26	59	62	52	58	20
		Periscope	86	86	71	81	64	79	57	67	36	43	43	40	14	14	36	21	50	55	52	52	14
		Range finder	86	93	86	88	71	79	64	71	36	43	43	40	21	14	29	21	54	57	55	55	16
		Mean	89	93	82	88	64	79	54	65	38	39	43	40	27	20	27	24	54	58	51	54	18
2	10	Unaided vision	100	100	100	100	100	100	71	90	21	50	21	31	29	36	14	26	62	71	52	62	32
		Binoculars	100	100	100	100	86	100	71	86	71	93	57	74	43	43	64	50	75	84	73	77	20
		Periscope	93	100	93	95	86	100	86	90	50	93	50	64	57	43	57	52	71	84	71	76	34
		Range finder	93	86	93	90	71	86	57	71	57	64	57	60	14	14	14	14	59	62	55	59	12
		Mean	96	96	96	96	86	96	71	85	50	75	46	57	36	34	38	36	67	75	63	68	25
3	20	Unaided vision	100	100	86	95	100	93	50	81	64	64	36	55	29	29	29	29	73	71	50	65	23
		Binoculars	93	93	86	90	93	93	43	76	71	64	64	67	36	71	29	45	73	80	55	70	11
		Periscope	93	93	79	88	100	100	57	86	43	64	36	48	21	14	29	21	64	68	50	61	23
		Range finder	100	93	86	93	79	93	64	79	50	93	36	60	36	43	36	38	66	80	55	67	16
		Mean	96	95	84	92	93	95	54	80	57	71	43	57	30	39	30	33	69	75	53	66	18
4	40	Unaided vision	93	93	86	90	79	93	71	81	79	57	29	55	50	36	21	36	75	70	52	65	25
		Binoculars	100	93	93	95	100	100	79	93	64	100	50	71	43	71	43	52	77	91	66	78	7
		Periscope	93	93	93	93	64	86	57	69	50	86	57	64	36	57	29	40	61	80	59	67	34
		Range finder	93	100	79	90	64	100	64	76	50	64	57	57	43	50	21	38	62	79	55	65	30
		Mean	95	95	88	92	77	95	68	80	61	77	48	62	43	54	29	42	69	80	58	69	24
5	80	Unaided vision	100	100	93	98	93	100	79	90	93	93	64	83	57	50	21	43	86	86	64	79	16
		Binoculars	93	100	93	95	93	86	71	83	79	86	64	76	57	64	36	52	80	84	66	77	14
		Periscope	100	100	100	100	79	71	50	67	43	64	36	48	21	43	07	24	61	70	48	60	20
		Range finder	93	93	86	90	79	93	57	76	50	71	57	60	50	57	50	52	68	79	62	70	25
		Mean	96	98	93	96	86	88	64	79	66	79	55	67	46	54	29	43	74	79	60	71	19
6	160	Unaided vision[b]	100	100	85	95	100	100	69	90	54	46	54	51	77	54	38	56	83	75	62	73	19
		Binoculars	93	100	93	95	100	100	64	88	64	71	36	57	93	86	64	81	88	89	64	80	11
		Periscope	100	93	86	93	93	93	64	83	21	71	36	43	57	86	36	60	68	86	55	70	25
		Range finder	93	100	86	93	86	93	79	86	64	86	64	71	86	86	79	83	82	91	77	83	32
		Mean	96	98	87	94	95	96	69	87	51	69	47	56	78	78	55	70	80	85	65	77	22
All locations		Unaided vision	98	98	89	95	87	94	63	81	58	58	40	52	47	36	25	36	72	71	54	66	23
		Binoculars	95	98	92	95	90	93	64	83	65	75	54	65	50	62	42	51	75	82	63	73	14
		Periscope	94	94	87	92	81	88	62	77	40	70	43	51	35	43	32	37	62	74	56	64	25
		Range finder	93	94	86	91	75	90	64	77	51	70	52	58	42	44	38	41	65	75	60	67	22
		Mean	95	96	88	93	83	91	63	79	54	68	47	56	43	46	34	41	69	75	58	68	21

[a]Includes both verified and unverified targets; to specify probabilities of detection, the false detection rates on blank trials (listed in the final column) were used to calculate deductions for guessing on the unverified targets.

[b]Observer N=13 for Unaided Vision.

Table C-2

Mean Number of Target Detections for Selected Time Intervals From Onset of Illumination

(Observer N = 14)

Viewing Method	Observer Location						All Locations
	1	2	3	4	5	6	
				10 Seconds			
Unaided vision	1.7	2.8	3.5	2.5	4.8	4.0	3.2
Binoculars	1.3	2.7	2.3	3.2	2.9	2.0	2.4
Periscope	.6	.8	.7	.2	.3	.3	.5
Range finder	.3	1.0	.9	.1	.6	.1	.5
All methods	1.0	1.8	1.8	1.5	2.2	1.6	
				15 Seconds			
Unaided vision	2.6	3.7	4.0	3.3	5.6	4.3	3.9
Binoculars	2.1	4.3	3.9	4.4	4.6	3.9	3.9
Periscope	1.6	1.5	1.5	.7	1.2	1.0	1.2
Range finder	.6	1.7	1.8	1.6	1.6	1.6	1.5
All methods	1.7	2.8	2.8	2.5	3.2	2.7	
				20 Seconds			
Unaided vision	2.8	4.2	4.4	4.1	6.5	4.9	4.5
Binoculars	3.0	5.0	5.0	5.1	5.7	4.8	4.8
Periscope	2.2	2.5	2.6	1.5	2.0	1.5	2.0
Range finder	1.1	2.2	2.8	2.1	2.2	2.5	2.2
All methods	2.3	3.5	3.7	3.2	4.1	3.4	
				30 Seconds			
Unaided vision	3.2	4.7	5.2	4.9	7.0	5.2	5.0
Binoculars	3.9	6.3	5.9	6.5	6.9	6.1	5.9
Periscope	3.0	4.3	3.7	3.1	3.0	2.6	3.3
Range finder	2.0	3.4	4.4	3.3	3.4	3.6	3.4
All methods	3.0	4.7	4.8	4.4	5.1	4.4	
				60 Seconds			
Unaided vision	4.1	5.3	5.8	5.8	8.0	6.1	5.8
Binoculars	5.2	7.3	7.0	8.2	8.2	7.6	7.2
Periscope	4.4	6.6	5.2	5.5	4.6	4.8	5.2
Range finder	4.7	5.8	6.4	5.3	5.6	6.1	5.6
All methods	4.6	6.2	6.1	6.2	6.6	6.2	
				120 Seconds			
Unaided vision	4.8	5.6	6.3	6.0	8.6	7.0	6.4
Binoculars	6.1	7.8	7.7	9.2	8.6	8.7	8.0
Periscope	5.4	7.5	6.0	6.3	6.0	6.8	6.3
Range finder	5.7	6.6	7.7	6.4	7.4	7.6	6.9
All methods	5.5	6.9	6.9	7.0	7.6	7.5	

Table C-3

Analysis of Variance of Differences in Number of Target Detections for Selected Time Intervals From Onset of Illumination

Source	*df*	Sum of Squares	Mean Square	*F* [a]
		Within 10 Sec.		
Observer location	5	45.8	9.2	1.5
Viewing method	3	479.7	159.9	26.5**
Interaction	15	90.6	6.0	2.1*
Error	312	887.8	2.8	
		Within 15 Sec.		
Observer location	5	70.5	14.1	3.1*
Viewing method	3	540.5	180.2	39.2**
Interaction	15	83.1	5.5	1.2
Error	312	1436.3	4.6	
		Within 20 Sec.		
Observer location	5	105.9	21.2	3.8**
Viewing method	3	534.0	178.0	31.8**
Interaction	15	95.1	6.3	1.1
Error	312	1744.2	5.6	
		Within 30 Sec.		
Observer location	5	146.8	29.4	5.1**
Viewing method	3	436.0	145.3	25.2**
Interaction	15	105.8	7.1	1.2
Error	312	1795.8	5.8	
		Within 60 Sec.		
Observer location	5	137.8	27.6	4.9**
Viewing method	3	205.5	68.5	12.3**
Interaction	15	128.2	8.6	1.5
Error	312	1740.3	5.6	
		Within 120 Sec.		
Observer location	5	162.1	32.4	5.7**
Viewing method	3	154.8	51.6	9.1**
Interaction	15	123.0	8.2	1.4
Error	312	1769.7	5.7	

[a] * denotes significance at the .05 level; ** denotes significance at the .01 level.

Appendix D

TARGET IDENTIFICATION DATA

Table D-1

Percentages of Targets Identified for Each Testing Condition[a] (Observer N=14)

Observer Location	Yards From Searchlight	Viewing Method	Target Distance (yd.)																All Distances				Blank Trials Identified as:		
			655				780				900				1055										
			Tank	APC	Jeep	Mean	Tank	APC	Jeep	Mean	Tank	APC	Jeep	Mean	Tank	APC	Jeep	Mean	Tank	APC	Jeep	Mean	Tank	APC	Jeep
1	0	Unaided vision	79	14	57	50	36	21	0	19	7	14	14	12	14	0	0	5	34	12	18	21	7	5	0
		Binoculars	86	79	29	64	64	29	21	38	29	14	29	24	29	0	0	10	52	30	20	34	9	2	4
		Periscope	71	29	36	45	50	36	21	36	29	14	14	19	0	7	14	7	38	21	21	27	9	4	2
		Range finder	64	43	57	55	64	29	14	36	21	29	14	21	14	0	14	10	41	25	25	30	2	0	5
		Mean	75	41	45	54	54	29	14	32	21	18	18	19	14	2	7	8	41	22	21	28	7	3	3
2	10	Unaided vision	64	50	64	60	79	14	36	43	7	21	0	10	7	0	0	2	39	21	25	29	14	0	9
		Binoculars	93	43	57	64	79	64	14	52	50	36	29	38	43	14	7	21	66	39	27	44	4	4	9
		Periscope	79	36	57	57	64	21	36	40	21	21	14	19	29	0	21	17	48	20	32	33	18	0	9
		Range finder	71	64	36	57	43	29	14	29	50	21	14	29	7	0	0	2	43	29	16	29	9	4	0
		Mean	77	48	54	60	66	32	25	41	32	25	14	24	21	4	7	11	49	27	25	34	11	2	7
3	20	Unaided vision	93	21	57	57	57	21	43	40	14	7	14	12	21	0	0	7	46	12	29	29	14	0	7
		Binoculars	86	71	57	71	79	43	14	45	64	36	29	43	36	14	7	19	66	41	27	45	5	0	5
		Periscope	93	29	57	60	86	21	29	45	14	14	7	12	7	0	7	5	50	16	25	30	16	4	2
		Range finder	93	29	36	52	43	29	21	31	43	29	7	26	29	0	7	12	52	21	18	30	7	0	4
		Mean	91	38	52	60	66	29	27	40	34	21	14	23	23	4	5	11	54	23	25	34	11	1	4
4	40	Unaided vision	64	36	50	50	43	21	7	24	29	14	21	21	43	0	0	14	45	18	20	27	16	2	4
		Binoculars	93	50	57	67	86	43	29	52	43	50	14	36	43	21	14	26	66	41	29	45	5	0	2
		Periscope	86	36	57	60	29	7	14	17	36	14	29	26	21	7	14	14	43	16	29	29	9	4	11
		Range finder	86	43	43	57	50	29	29	36	21	14	21	19	29	14	7	17	46	25	25	32	12	2	0
		Mean	82	41	52	58	52	25	20	32	32	23	21	26	34	11	9	18	50	25	25	33	11	2	4
5	80	Unaided vision	100	29	64	64	57	43	29	43	36	29	36	33	29	7	7	14	55	27	34	39	9	2	2
		Binoculars	93	86	71	83	79	57	29	55	50	50	36	45	43	21	21	29	66	54	39	53	9	2	2
		Periscope	93	29	21	48	57	7	14	26	21	14	7	14	21	7	0	10	48	14	11	24	11	0	4
		Range finder	86	64	50	67	57	50	7	38	21	29	36	29	36	14	21	24	50	39	29	39	5	2	7
		Mean	93	52	52	65	62	39	20	40	32	30	29	30	32	12	12	19	55	33	28	39	8	1	4
6	160	Unaided vision	92	38	54	62	85	62	46	64	8	15	23	15	38	15	0	18	56	33	31	40	2	0	10
		Binoculars	93	86	64	81	100	57	14	57	36	36	14	29	86	36	21	48	79	54	29	54	5	2	0
		Periscope	93	57	21	57	93	50	29	57	0	36	7	14	43	36	21	33	57	45	20	40	9	4	2
		Range finder	86	79	64	76	86	64	21	57	29	29	36	31	71	36	14	40	68	52	34	51	12	0	7
		Mean	91	65	51	69	91	58	27	59	18	29	20	22	60	31	15	35	65	46	28	46	7	1	5
All locations		Unaided vision	82	31	58	57	59	30	27	39	17	17	18	17	25	4	1	10	46	20	26	31	11	2	5
		Binoculars	90	69	56	72	81	49	20	50	45	37	25	36	46	18	12	25	66	43	28	46	6	1	4
		Periscope	86	36	42	54	63	24	24	37	20	19	13	17	20	10	13	14	47	22	23	31	12	2	5
		Range finder	81	54	48	61	57	38	18	38	31	25	21	26	31	11	11	17	50	32	24	35	8	1	4
		Mean	85	47	51	61	65	35	22	41	28	24	19	24	31	10	9	17	52	29	25	36	9	2	4

[a]Includes all correctly identified targets; to specify probabilities of identification, data from false identifications on blank trials (listed in the final column) were used to calculate deductions for guessing.

Table D-2

Analysis of Variance of Mean Differences for Probability of Identification

Source	*df*	Mean Square	F[a]
Observer location	5	136.2	8.3**
Viewing method	3	327.7	20.0**
Interaction	15	16.4	
Total	23		

[a]**denotes significance level of .05.

Appendix E

TARGET DETECTION AND IDENTIFICATION, BY TARGET DISTANCE

Target Detection and Target Distance by Observer Location

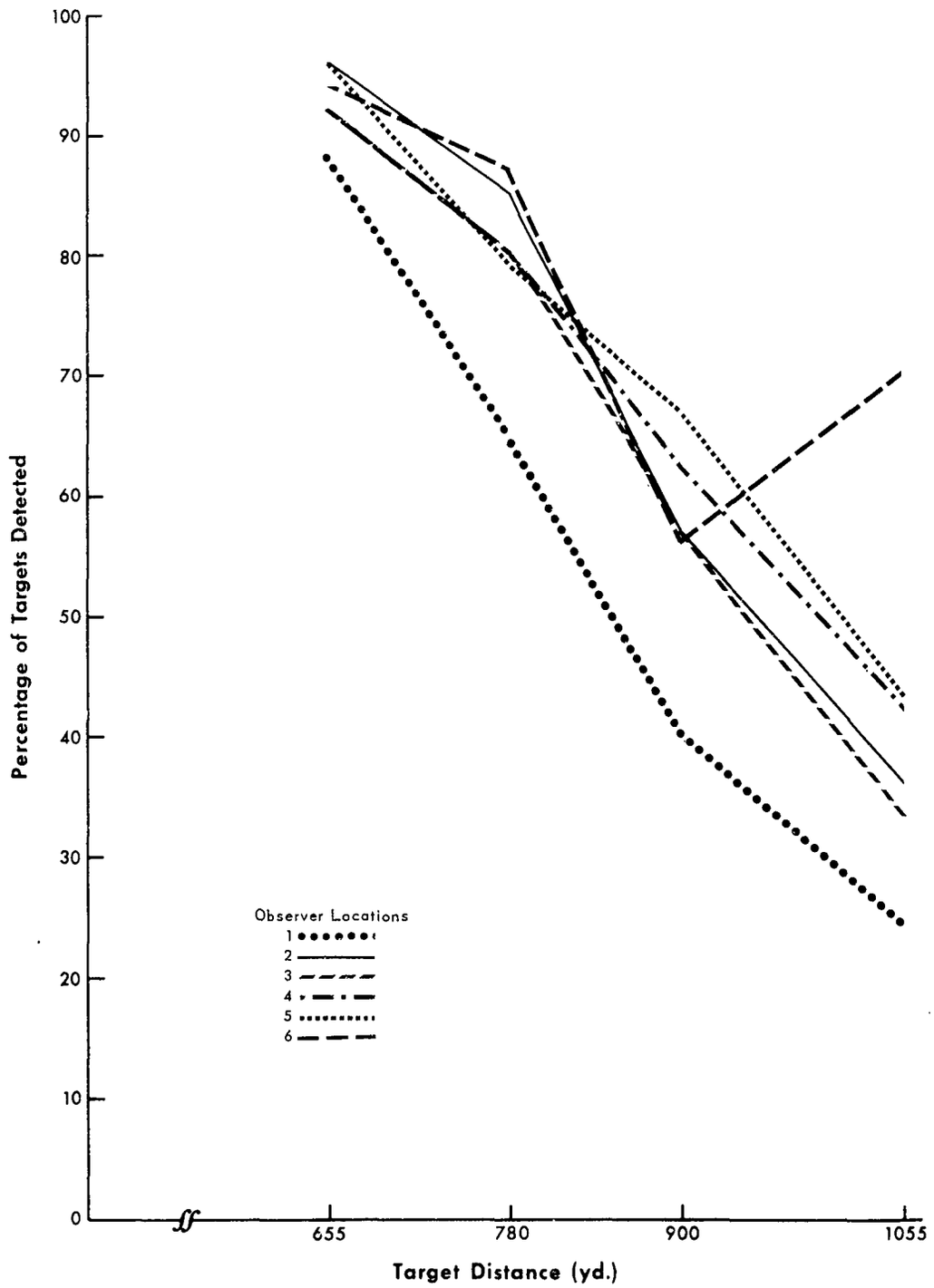

Figure E-1

Target Identification and Target Distance by Observer Location

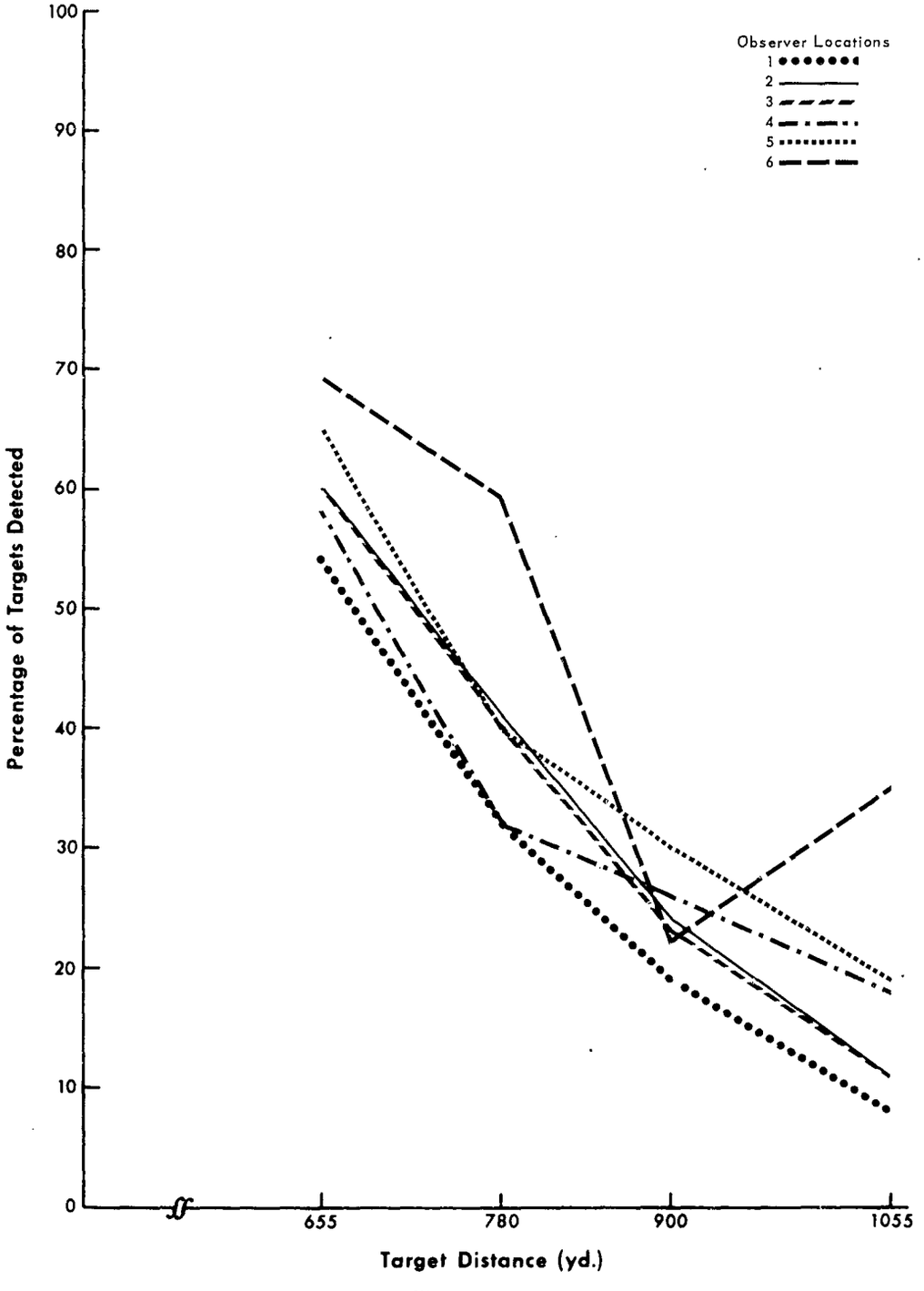

Figure E-2

Target Detection and Target Distance by Viewing Method

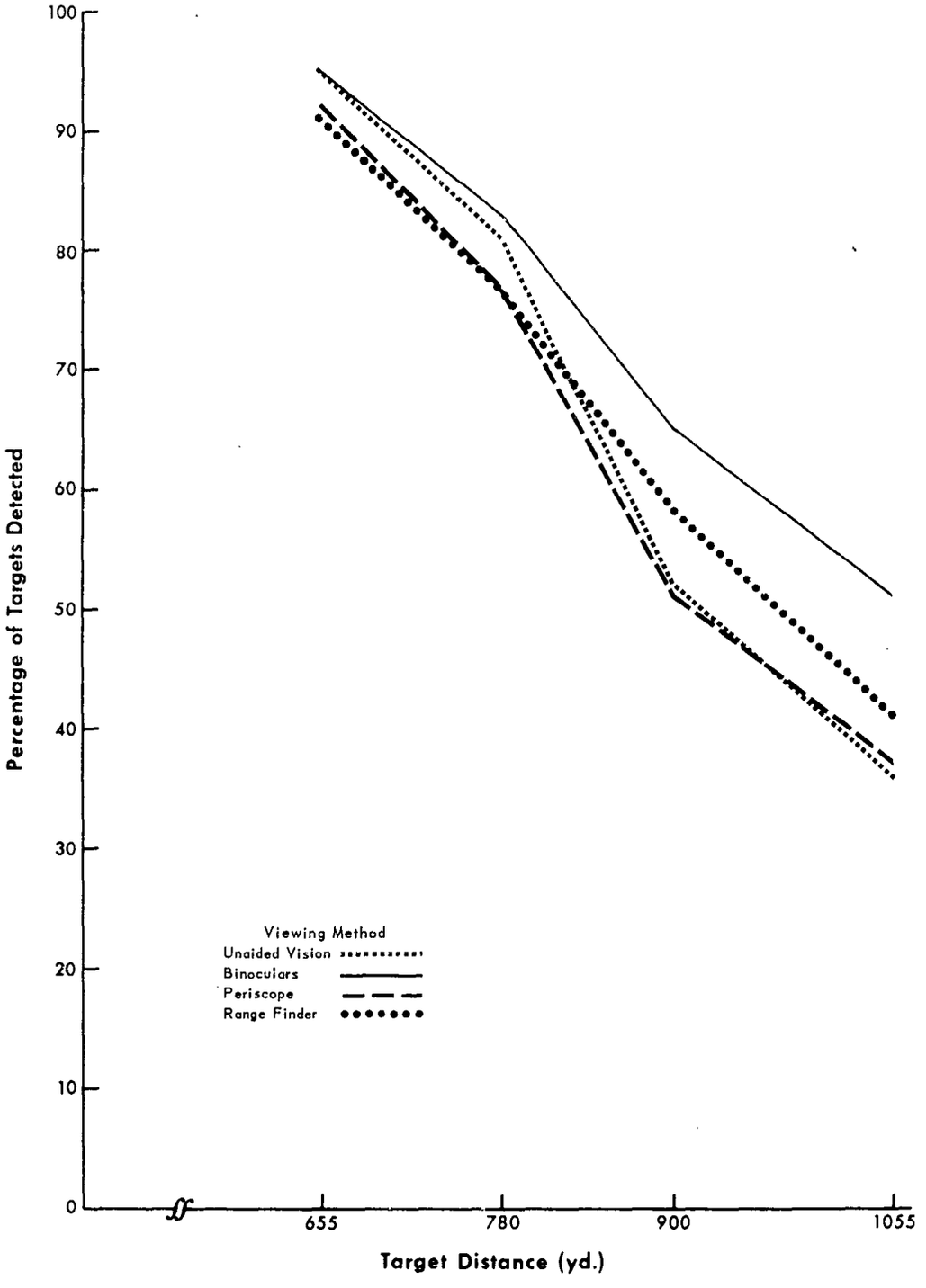

Figure E-3

Target Identification and Target Distance by Viewing Method

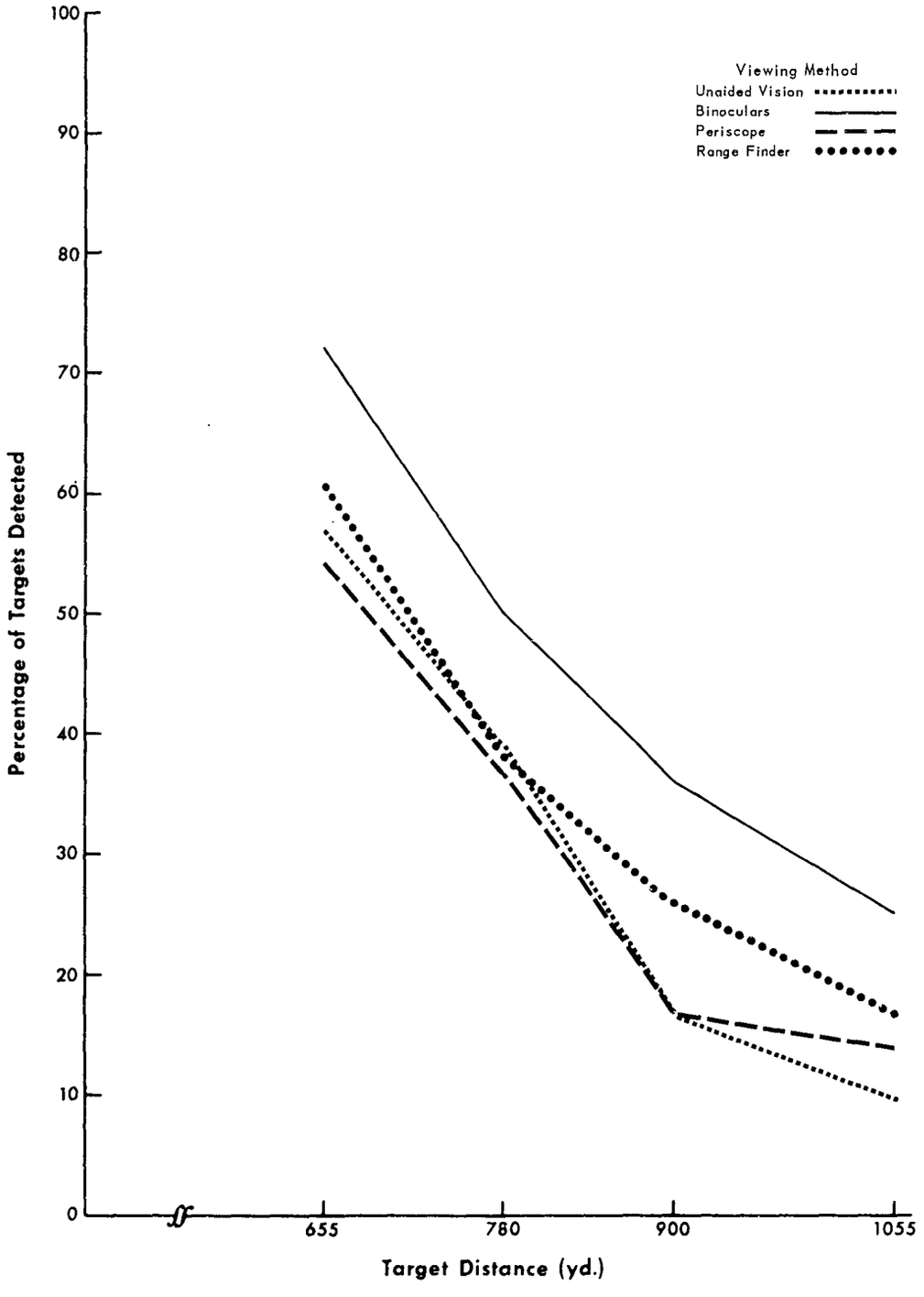

Figure E-4

Target Detection and Target Distance by Type of Target

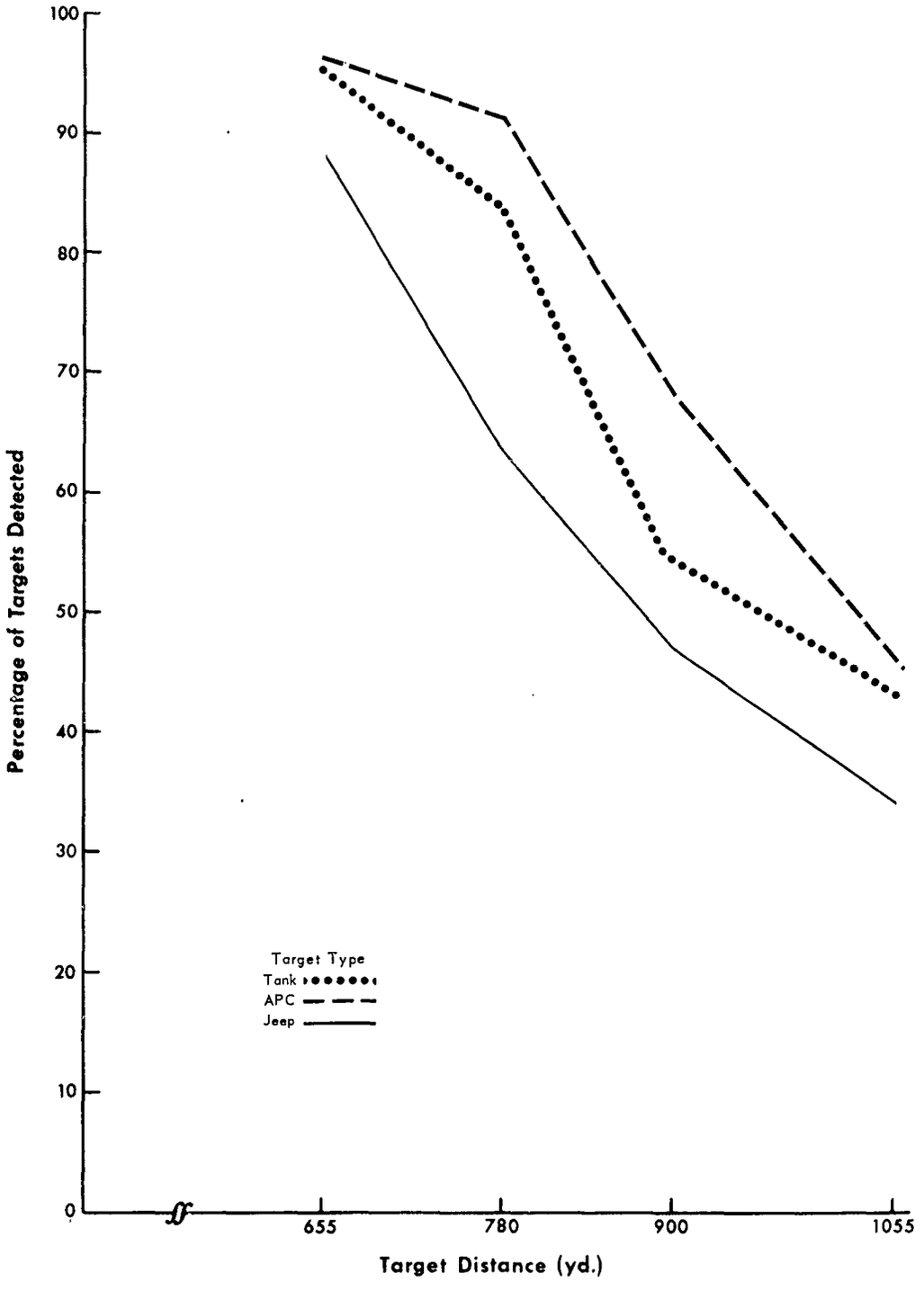

Figure E-5

Target Identification and Target Distance by Type of Target

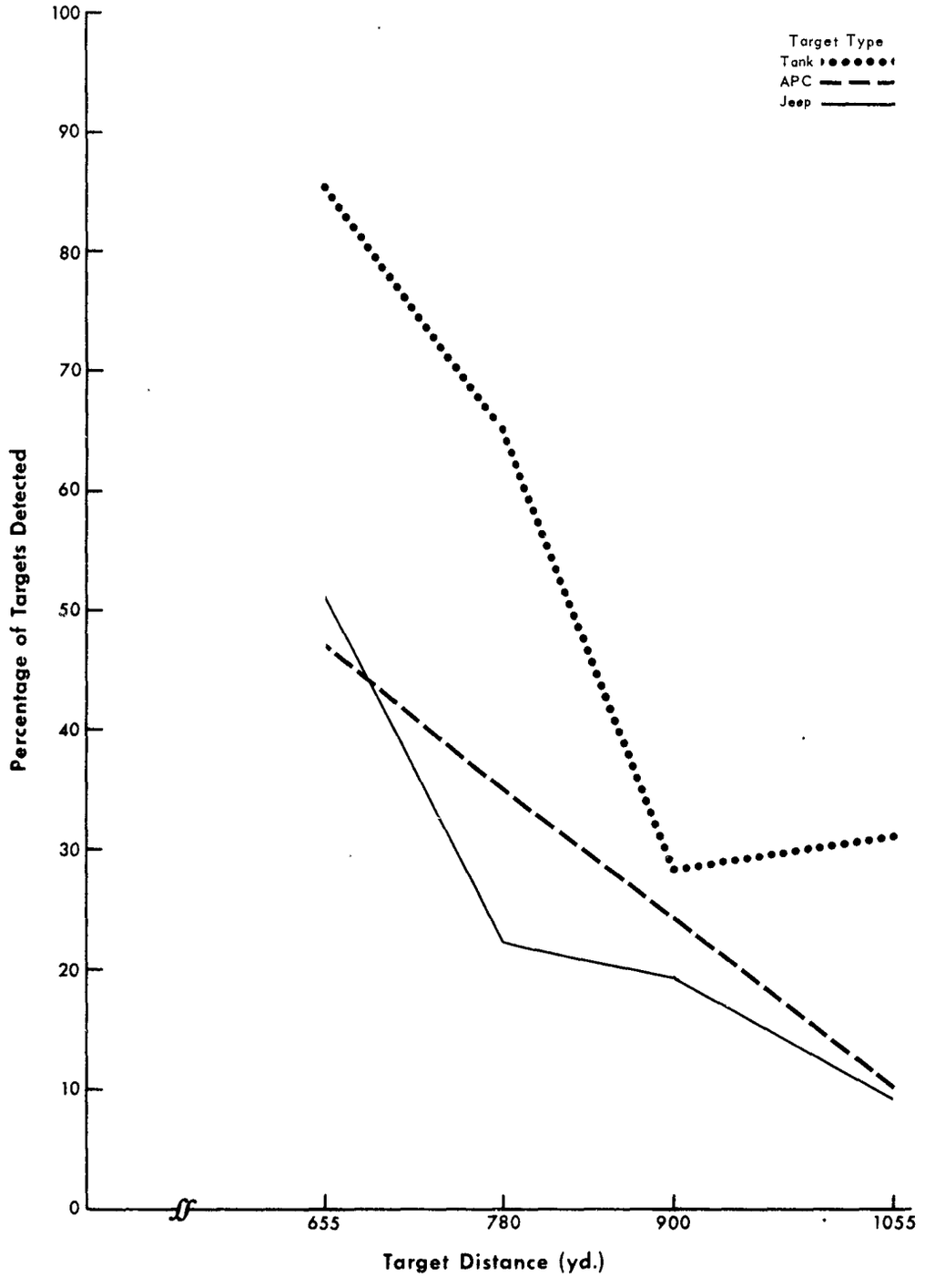

Figure E-6

DISTRIBUTION LIST

2 DIR OF RES TNG METHODS DIV HUMRRO
2 DIR OF RES LANG + AREA TNG DIV HUMRRO
1 MILIT ADV HUMAN FACTORS + OPNS RES DIV ARMY RES OFC HUMRRO
5 DIR OF RES ARMY ARMOR HRU FT KNOX
3 DIR OF RES ARMY TNG CTR HRU PRES OF MONTEREY
5 DIR OF RES ARMY INF HRU FT BENNING
5 DIR OF RES ARMY AIR DEF HRU FT BLISS
2 DIR OF RES ARMY AVN HRU FT RUCKER
10 CG US CONARC FT MONROE ATTN DCS IT
1 CHF OF R+D DA ATTN SCI INFO BR RES SPT DIV
2 HUMAN FACTORS + OPNS RES DIV ARMY RES OFC OFC CHF OF R+D
2 DIR MANPOWER REQUIREMENTS + UTILIZATION OASD MANPOWER SS+R
1 DIR WEAPONS SYS EVAL GP
2 SCI + TECH INFO FACILITY ATTN NASA REP S-AK-DL
1 CINC US ARMY PACIFIC APO 958 SAN FRAN ATTN G3 CBT DEVEL DIV
2 CG SOUTHERN EUROPEAN TASK FORCE APO 168 NY
1 CG US ARMY JAPAN APO 343 SAN FRAN ATTN G3
2 CG US ARMY CARIBBEAN APO 834 N ORLEANS ATTN CARCD
2 CG US ARMY ALASKA APO 949 SEATTLE ATTN ARACD
2 CG US ARMY EUROPE APO 403 NY ATTN OPNS DIV
1 CO ARMY TRANS RES COMD FT EUSTIS ATTN TECH LIB
6 CG FIRST ARMY GOVERNORS ISL NY ATTN G3
6 CG SECOND ARMY FT GEO G MEADE ATTN DCSOT
1 CG THIRD ARMY FT MCPHERSON
1 CG FOURTH ARMY FT SAM HOUSTON ATTN G3
7 CG FIFTH ARMY CHICAGO ATTN ALFGC TNG
1 CG SIXTH ARMY PRES OF SAN FRAN ATTN AMAAV
1 HQ SEVENTH ARMY OFC OF CHEM OFFR APO 46 NY
1 CG EIGHTH ARMY APO 301 SAN FRAN ATTN AG-AC
2 CG EIGHTH ARMY APO 301 SAN FRAN ATTN G3
1 CLIN PSYCHOL SERV DEPT OF NEUROPSYCHIAT WALTER REED GEN HOSP
1 DIR HUMAN ENGNR LABS ABERDEEN PG
2 ENGNR PSYCHOL LAB PIONEERING RES DIV ARMY NATICK LABS NATICK MASS
4 TECH LIB ARMY NATICK LABS NATICK MASS
3 CO ARMY CHEM R+D LABS EDGEWOOD ARSNL MD ATTN LIBN
1 CO ARMY CBT DEVEL COMD CHEM BIOL + RADIOL AGY FT MCCLELLAN
1 CO ARMY PICTORIAL CTR LONG ISL ATTN APPLICAT DEVEL BR TV DIV
1 CG ARMY ELEC PG FT HUACHUCA ATTN TECH LIB
12 CO 1ST AIR DEF GUIDED MSL BRGD TNG FT BLISS
1 CG ARMY CBT DEVEL COMD EXPRM CTR FT ORD
1 SIXTH ARMY LIB DEPOT PRES OF SAN FRAN
1 CHF DEPT OF CLIN + SOC PSYCHOL WALTER REED ARMY INST OF RES
WALTER REED ARMY MED CTR
5 CG FT ORD ATTN G3 TNG DIV
1 CO DUGWAY PG UTAH ATTN TECH LIB
1 DIR WALTER REED ARMY INST OF RES WALTER REED ARMY MED CTR
1 DIR WALTER REED ARMY INST OF RES WALTER REED ARMY MED CTR
ATTN NEUROPSYCHIAT DIV
1 CO HQ ARMY ENLISTED EVAL CTR FT BENJ HARRISON
1 DPTY FOR BIOASTRONAUT PG AIR PG CTR EGLIN AFB
1 DIR ARMY ENGNR R+D LABS FT BELVOIR ATTN TECH DOCU CTR
1 CO FRANKFORD ARSNL ATTN SMUFA 1031/65-1
2 WALTER REED ARMY INST OF RES ATTN DEPT OF PSYCHIAT NEUROPSYCHIAT DIV
1 CG 5TH RGN USARADCOM FT SHERIDAN ATTN G3 TNG
3 6TH RGN USARADCOM FT BAKER
2 11TH AIR ASSAULT DIV FT BENNING
1 PERS SUBSYS DIV CREW SUBSYS DRCT AERONAUT SYS DIV WRIGHT-PATTERSON AFB
1 DIR ARMY BD FOR AVN ACCIDENT RES FT RUCKER
1 FIRST ARMY MSL COMD MED APO 221 NY
2 CO PICATINNY ARSNL DOVER N J ATTN SUMPA VCI
1 DEF SUPPLY AGY CAMERON STATION ATTN LIB
1 CBT OPNS RES GP ARMY CBT DEVEL COMD FT BELVOIR
ATTN OPNS ANLS HUMAN FACTORS
1 CO ARMY CBT DEVEL COMD FT BENNING ATTN INF AGY
1 CO ARMY CBT DEVEL COMD FT KNOX ATTN ARMOR AGY
8 ARMY CBT DEVEL COMD FT BRAGG ATTN SPEC WARFARE AGY
1 EVAL DIV OAO ARMY SIG CTR + SCH FT MONMOUTH
3 CO ARMY CBT DEVEL COMD SPEC DOCTRINE + EQUIPMENT GP FT BELVOIR
3 ARMY WAR COLL CARLISLE BKS ATTN LIB
1 ASST COMDT ARMY INTEL SCH FT HOLABIRD ATTN PLANS DIV OAO
1 COMDT COMD + GEN STAFF CO FT LEAVENWORTH ATTN ARCHIVES
1 DIR OF MILIT PSYCHOL + LDRSHP US MILIT ACAD WEST POINT
1 US MILIT ACAD WEST POINT ATTN LIB
1 COMDT ARMY AVN SCH FT RUCKER ATTN SCH LIB
2 COMDT ARMY SECUR AGY TNG CTR + SCH FT DEVENS ATTN LIB
1 MED FLD SERV SCH BROOKE ARMY MED CTR FT SAM HOUSTON ATTN STIMSON LIB
10 DIR OF INSTR ARMOR SCH FT KNOX
1 COMDT ARMY ARMOR SCH FT KNOX ATTN WEAPONS DEPT
1 COMDT ARMY CHAPLAIN SCH FT SLOCUM
1 COMDT ARMY CHEM CORPS SCH FT MCCLELLAN ATTN EDUC ADV
4 COMDT ARMY ADJ GEN SCH FT BENJ HARRISON ATTN EDUC ADV
1 ARMY INF SCH FT BENNING ATTN EDUC ADV
1 ARMY QM SCH FT LEE ATTN LIB
1 COMDT ARMY TRANS SCH FT EUSTIS ATTN EDUC ADV
1 COMDT ARMY MILIT POLICE SCH FT GORDON ATTN DIR OF INSTR
1 COMDT ARMY SOUTHEASTERN SIG SCH FT GORDON
1 CG ARMY ORD CTR + SCH ABERDEEN PG ATTN AISO-SL
1 ASST COMDT ARMY AIR DEF SCH FT BLISS ATTN CLASSF TECH LIB
10 CG ARMY ARTY + MSL CTR FT SILL ATTN AVN OFFR
1 COMDT ARMED FORCES STAFF COLL NORFOLK
1 COMDT ARMY SIG SCH FT MONMOUTH ATTN EDUC COORD
1 COMDT JUDGE ADVOCATE GEN SCH U OF VA
1 EDUC CONSLT ARMY MILIT POLICE SCH FT GORDON
6 COMDT ARMY ENGNR SCH FT BELVOIR ATTN AIBBES-SY
1 CHF POLICY + TNG LIT DIV ARMY ARMOR SCH FT KNOX
1 COMDT ARMY AVN SCH FT RUCKER ATTN EDUC ADV
1 COMDT ARMY PRIMY HEL SCH FT WOLTERS
1 DIR OF MILIT INSTR US MILIT ACAD WEST POINT
1 SPEC WARFARE SCH FT BRAGG ATTN LIB
2 SECY ARMY ORDNANCE GUIDED MISSILE SCH REDSTONE ARSNL
2 HQ ABERDEEN PG ATTN TECH LIB
1 COMDT ARMY QM SCH OFC DIR OF NONRESID ACTVY FT LEE ATTN TNG MEDIA DIV
1 SECY OF ARMY
1 DCS-PERS DA ATTN CHF C+S DIV
1 CO FOREIGN SCI + TECH CTR MUN BLDG
2 AGS FOR FORCE DEVEL DA ATTN CHF TNG DIV
1 HQ ARMY MAT COMD R+D DRCTE ATTN AMCRD-RC
1 CHF OF PERS OPNS OFCR PERS DRCTE DA ATTN SIG BR
1 CLIN PSYCHOL CONSLT OFC OF CHF PSYCHIAT + NEUROL CONSLT OFC OF SURG GEN
ATTN LT COL MSC
2 CG ARMY MED R+D COMD ATTN BEHAV SCI RES BR
1 ARMY PERS RES OFC ATTN CRD-AR
2 OFC OF PERS OPNS DA ATTN OPOSS-A
1 STANDARDS + SYS OFC OPO OCCUP R+D SECT ATTN OPOSS-A
1 ARMY PROVOST MARSHAL GEN
1 OFC RESERVE COMPON DA
2 CHF ARMY SECUR AGY ARLINGTON HALL STA ATTN ACS-G1
20 CDR DEF DOCUMENTATION CTR CAMERON STA
1 CG ARMY ELECT COMD FT MONMOUTH ATTN AMSEL CB
1 CHF OF R+D DA ATTN CHF TECH + INDSTR LIAISON OFC
1 EDUC + TNG BR CBT DEVEL + OPNS DIV OFC OF CHF SIG OFFR DA
1 PERS + TNG DIV ORDHC OFC OF CHF OF ORD DA
2 CG ARMY MED R+D COMD ATTN MEDDH-SR
1 ARMY PERS RES OFC ATTN CRD-AIC
1 COMDT ARMY CBT SURVEIL SCH FT HUACHUCA ATTN ATSUR S3
1 CG ARMY AIR DEF COMD ENT AFB
2 PRES ARMY ARMOR BD FT KNOX
1 PRES ARMY INF BD FT BENNING ATTN FE+SP DIV
1 PRES ARMY MAINT BD FT KNOX
2 PRES ARMY AVN TEST BD FT RUCKER
2 PRES ARMY ARTY BD FT SILL
1 DPTY PRES ARMY MAT COMD BD ABERDEEN PG
1 PRES ARMY TRANS BD FT EUSTIS
1 OFC OF SURG 1ST ARMORED DIV FT HOOD
1 CG 2D ARMORED DIV FT HOOD ATTN DIV AVN OFCR
10 CG 4TH ARMORED DIV APO 326 NY
1 CG 4TH ARMOR GP APO 757 NY
2 CO 16TH ARMOR GP FT IRWIN
5 CO 2D ARMORED CAV REGT APO 696 NY
1 CO 3D ARMORED CAV REGT APO 34 NY
4 CO 11TH ARMORED CAV REGT APO 305 NY
4 CO 14TH ARMORED CAV REGT APO 26 NY
2 CG ARMY ARMOR + ARTY FIRING CTR FT STEWART ATTN ACS-G3 TNG OFCR
1 1ST ARMORED DIV HQ+HQ CO FT HOOD ATTN ACS-G2
1 1ST CAV DIV 3D MED TANK BN 40TH ARMOR APO 24 SAN FRAN
5 1ST INF DIV 1ST MED TANK BN 63D ARMOR FT RILEY
8 3D INF DIV 1ST BN 64TH ARMOR APO 36 NY
10 CDR 1ST BN 34TH ARMOR FT LEWIS
2 1ST TANK BN 73D ARMOR 7TH INF DIV APO 7 SAN FRAN
8 8TH INF DIV 2D BN 68TH ARMOR APO 34 NY
1 CO COMPANY A 3D BN 32D ARMOR 3D ARMORED DIV (SPEARHEAD) APO 39 NY
1 CO 1ST BN 69TH ARMOR APO 25 SAN FRAN
1 CO 5TH BN 33D ARMOR FT KNOX
1 CO 3D MED TANK BN 68TH ARMOR APO 28 NY ATTN S3
1 CO 3D MED TANK BN 37TH ARMOR APO 36 NY
1 CO 4TH MED TANK BN 68TH ARMOR APO 28 NY
5 CO 2D BN 34TH ARMOR FT IRWIN
2 CALIF NG 40TH ARMORED DIV LOS ANGELES ATTN ACS-G3
1 55TH COMD HQ DIV ARMY NG JACKSONVILLE FLA
4 CO 150TH AVN BN NJ AIR NG ELIZABETH
1 CG HQ 27TH ARMORED DIV NY AIR NG SYRACUSE
1 TEXAS NG 49TH ARMORED DIV DALLAS
6 CO 3D MED TANK BN 32D ARMOR APO 29 NY
1 CG ARMY ARMOR CTR FT KNOX ATTN G3 AIBKGT
2 CG 1ST INF DIV FT RILEY ATTN G3
1 CG 2D INF DIV FT BENNING ATTN DIV AVN COMDR
3 CG 4TH INF DIV FT LEWIS ATTN G3
1 CG 8TH INF DIV APO 111 NY ATTN G2
1 CG 5TH INF DIV (MECH) FT CARSON
5 CG 24TH INF DIV APO 112 NY ATTN G3
3 CG 82D ABN INF DIV FT BRAGG ATTN G3
1 CO 1ST BN (REINF) 3D INF (THE OLD GUARD) FT MEYER
1 CO HQ 2D BN 6TH INF REGT APO 742 NY
7 CO 3D BN 4TH INF REGT APO 742 NY
1 CO 171ST INF BRGD APO 731 SEATTLE
3 CG 25TH INF DIV APO 25 SAN FRAN
1 CO 4TH BG 30TH INF FT SILL
1 CO 2D BG 31ST INF REGT FT RUCKER
1 CO 3D BN 19TH INF APO 29 NY
1 CO 1ST BN 39TH INF APO 28 NY
5 CO 1ST BN (MECH) 52D INF 1ST ARMORED DIV (OLD IRONSIDES) FT HOOD
7 4TH BN (MECH) 54TH INF FT KNOX
1 CO ARMY PARTIC GP NAV INTI-DEVICE CTR PT WASHINGTON ATTN CODE 01A
2 CHF AUDIO VISUAL APPLICAT OFC ARMY PICTORIAL DIV OFC OF CHF SIG OFCR
1 CHF MED RES PROJ ARMY HOSP US MILIT ACAD WEST POINT
1 CG MILIT DIST OF WASHINGTON
1 TECH DIR R+E DIV OFC OF QM GEN
2 HQ ARMY LIAISON GP PROJ MICH U OF MICH
1 SYS RES GP ENGNR EXPRM STA COLUMBUS O
1 DIR ARMY LIB
1 STRATEGIC PLANNING GP CORPS OF ENGNR ARMY MAP SERV
1 CHF OF MILIT HIST DA ATTN GEN REF BR
1 82D ABN DIV FT BRAGG
1 CO 56TH ARTY BRGD AIR DEF FT BANKS
1 CG 31ST ARTY BRGD AIR DEF OAKDALE PENNA
1 28TH ARTY GP AIR DEF SELFRIDGE AFB
1 52D ARTY BRGD AIR DEF HIGHLANDS AFS
1 HQ NIAGARA-BUFFALO DEF 31ST ARTY BRGD AIR DEF LOCKPORT
1 HQ 45TH ARTY BRGD AIR DEF ARLINGTON HTS ILL
1 CO ARMY AVN TEST BD FT RUCKER
1 CG 101ST ABN DIV FT CAMPBELL
1 CG 1ST CAV DIV APO 24 SAN FRAN
1 ARMY QM R+E FEA FT LEE ATTN TECH LIB
1 CHF BEHAV SCI RES BR ARMY MED R+D COMD
2 PRES ARMY FINANCE CORPS BR
1 ARMY R+D OFC PANAMA FT CLAYTON CANAL ZONE ATTN BEHAV SCI COORD
1 CO ARMY RES OFC DURHAM
2 CINC US PACIFIC FLT FPO SAN FRAN
1 CINC PACIFIC OPNS ANLS SECT FPO SAN FRAN
1 CHF BUR OF MED + SURG DN ATTN CODE 513
1 CHF RES DIV BUR OF MED + SURG DN
1 HEAD CLIN PSYCHOL SECT PROFESNL DIV BUR OF MED + SURG DN
1 BUR OF NAV PERS ATTN TECH LIB PERS 11B
3 DIR PERS RES DIV BUR OF NAV PERS
1 BUR OF YDS + DKS DN ATTN ASST CHF FOR RES DEVEL TEST + EVAL
3 CHF OF NAV PERS
1 CO + DIR NAV TNG DEVICE CTR PT WASHINGTON ATTN LIBN
2 NAV MSL CTR POINT MUGU CALIF ATTN HUMAN FACTORS ENGNR DIV
1 CO NAV AIR DEVEL CTR JOHNSVILLE PENNA ATTN NADC LIB
1 CO FLT TNG CTR NAV BASE NEWPORT
1 CDR FLT TNG GP NAV BASE CHARLESTON
2 HUMAN FACTORS DEPT COMM PSYCHOL DIV NAV TNG DEVICE CTR PT WASHINGTON
1 CLIN PSYCHOL MENTAL HYGIENE UNIT US NAV ACAD ANNAPOLIS
1 PRES NAV WAR COLL NEWPORT ATTN MAHAN LIB
2 CO + DIR ATI-UNIT FLT ANTI-SUB WARFARE TACTICAL SCH NORFOLK
1 CHF OF NAV RES ATTN HEAD PERS + TNG BR CODE 458
1 CHF OF NAV RES ATTN DIR PSYCHOL SCI DIV CODE 450
1 CHF OF NAV RES ATTN HEAD GP PSYCHOL BR CODE 452
1 OIC NAV PERS RES ACTVY NAV YD WASHINGTON
5 CO OFC OF NAV RES BR OFC FPO 39 NY
1 CHF OF NAV AIR TNG TNG RES DEPT NAV AIR STA PENSACOLA
1 CO NAV SCH OF AVN MED NAV AVN MED CTR PENSACOLA
1 NAV MED RES LAB NAV SUB BASE GROTON ATTN LIB
1 CO MED FLD RES LAB CAMP LEJEUNE

1 COR NAV MSL CTR POINT MUGU CALIF ATTN TECH LIB CODE 3022
1 OIC NAV PERS RES ACTVY SAN DIEGO
1 NAV AIR TECH TNG CTR MEMPHIS
1 NAV NEUROPSYCHIAT RES UNIT SAN DIEGO
2 COR NAV MSL CTR POINT MUGU CALIF ATTN HUMAN ENGNR DIV CODE N-335
1 OIC NAV PERS RES ACTVY NAV STA NAV YD ANNEX WASHINGTON
2 COMTRL NAV BASE NORFOLK
1 COMDT MARINE CORPS HQ MARINE CORPS ATTN CODE AO-1B
1 HQ MARINE CORPS ATTN AX
1 DIR MARINE CORPS EDUC CTR MARINE CORPS SCH QUANTICO
ATTN SECRET + CONF FILES GP
1 DIR MARINE CORPS INST ATTN EVAL UNIT
1 CHF OF NAV OPNS OP-01P1
1 CHF OF NAV OPNS OP-07T2
1 CHF OF NAV AIR TECH TNG NAV AIR STA MEMPHIS
2 COMDT PTP COAST GUARD HQ
1 CHF OFCR PERS RES + REVIEW BR COAST GUARD HQ
1 CINC STRATEGIC AIR COMD OFFUTT AFB ATTN SUP-3
3 DIR OF PERS PROCUR + RETENTION AIR FORCE MILIT PERS CTR RANDOLPH AFB
1 CHF SCI DIV DRCTE SCI + TECH DCS R+D HQ AIR FORCE AFRSTA
1 CHF OF PERS RES BR DRCTE OF CIVILIAN PERS DCS-PERS HQ AIR FORCE
1 CHF EVAL BR(AFPDPCE) CAREER DEVEL DIV DRCTE OF PERS PLAN HQ AIR FORCE
2 DPTY INSPECTOR GEN AIR FORCE (AFIAS-G1) NORTON AFB
1 CHF COMM STUDY GP SAFOIXD BOLLING AFB STOP B-20
1 FED AVN AGY MED LIB HQ-640
2 HQ AIR FORCE STAFF COLL SCGB 3 ANDREWS AFB
2 SACRAMENTO AIR MAT AREA SMACU-PERS RES MCCLELLAN AFB
1 AERO MED RES LAB MRPTO WRIGHT-PATTERSON AFB
1 AIR MOVEMENT DESIGNATOR MRPTO WRIGHT-PATTERSON AFB
1 HQ BALLISTICS SYS DIV PERS SUBSYS BR BSOSP NORTON AFB
2 MILIT TNG CTR OPE LACKLAND AFB
2 6570TH AERO MED RES LAB MRPT WRIGHT-PATTERSON AFB
1 AIR MOVEMENT DESIGNATOR AMRH BROOKS AFB
2 HQ AIR TRANS COMD ATCTD-M RANDOLPH AFB
1 DIR AIR U LIB MAXWELL AFB ATTN AUL3T-63-253
1 AIR FORCE SCH OF AEROSPACE MED BROOKS AFB ATTN AEROMED LIB
1 DIR OF LIB US AIR FORCE ACAD
1 DRCTE OF AEROSPACE SAFETY AFIAS-L DPTY IG NORTON AFB
1 COMDR ARCTIC AEROMED LAB APO 731 SEATTLE
1 6570TH PERS RES LAB PRA-4 AEROSPACE MED DIV LACKLAND AFB
3 CENTRAL INTEL AGY ATTN OCR MAIL RM
1 DEPT OF STATE BUR OF INTEL + RES EXTERNAL RES STAFF
1 SCI INFO EXCH WASHINGTON
2 CHF REGL TNG BR TNG DIV FED AVN AGY ATTN PT 38
1 RES INFO CTR NATL BUR OF STANDARDS ATTN RES PSYCHOL
1 CHF PSYCHOL BR CIVIL AEROMED RES INST FED AVN AGY OKLAHOMA CITY
1 SYS DEVEL CORP SANTA MONICA ATTN LIB
2 DUNLAP + ASSOC INC DARIEN ATTN LIB
2 RES ANLS CORP BETHESDA
1 RAND CORP WASHINGTON ATTN LIB
1 U OF SO CALIF ELEC PERS RES GP
1 COLUMBIA U ELEC RES LABS ATTN TECH EDITOR
1 MITRE CORP BEDFORD MASS ATTN LIB
1 WESTERN ELECTRIC CO WINSTON-SALEM
2 U OF PGH LEARNING R+D CTR ATTN DIR
1 HUMAN SCI RES INC NORFOLK
1 HUMAN ECOLOGY FUND WASHINGTON
1 HUMAN SCI RES INC MCLEAN VA
2 TECH INFO CTR ENGNR DATA SERV N AMER AVN INC COLUMBUS O
1 CHRYSLER CORP MSL DIV DETROIT ATTN TECH INFO CTR
1 AVCO CORP LAWRENCE MASS ATTN MANGR HUMAN FACTORS DEPT
1 SORO AMER U ATTN LIBN
2 EDUC + TNG CONSULTANTS LOS ANGELES ATTN PRINCIPAL SCI
1 INFO SYS DEPT 197 SPACE + INFO SYS DIV N AMER AVN INC DOWNEY CALIF
1 GEN DYNAMICS POMONA CALIF ATTN LIB
1 BELL AEROSYS CO CASTLE AFB
1 AVN CRASH INJURY RES SKY HARBOR AIRPORT PHOENIX ATTN TECH LIBN
2 MARQUARDT CORP POMONA CALIF ATTN DEPT 580
2 REFLECTONE ELEC INC STAMFORD CONN
1 CHF PERS SUBSYS AIRPLANE DIV MS 74-90 RENTON WASH
1 SYLVANIA ELECTRIC PRODUCTS INC NEEDHAM HGTS MASS ATTN PERS SUBSYS MANGR
1 THIOKOL CHEM CORP HUMETRICS DIV LOS ANGELES ATTN LIBN
2 SORO FLD OFC OFC OF SECY SPEC WARFARE SCH FT BRAGG
1 DIR OF RELIABILITY + VALUE ENGNR BELL AEROSYS CO BUFFALO
1 INST FOR DEF ANLS RES + ENGNR SUPPORT DIV WASHINGTON
1 DIR CTR FOR RES ON LEARNING + TEACHING U OF MICH
1 EDITOR TNG RES ABSTR AMER SOC OF TNG DIRS U OF TENN
1 U OF CHICAGO DEPT OF SOC
1 GEO WASHINGTON U DEPT OF PSYCHOL
1 HUMAN FACTORS SECT R+D GEN DYNAMICS ELECTRIC BOAT GROTON
1 DIR SORO AMER U

6 BRITISH EMBSY BRITISH DEF RES STAFF WASHINGTON
3 CANADIAN JOINT STAFF OFC OF DEF RES MEMBER WASHINGTON
3 CANADIAN ARMY STAFF WASHINGTON ATTN GSO2 TNG
2 CANADIAN LIAISON OFCR ARMY ARMOR BD FT KNOX
3 ACS FOR INTEL FOREIGN LIAISON OFCR TO NORWEG MILIT ATTACHE
2 ACS FOR INTEL FOREIGN LIAISON OFCR FOR SWEDISH EMBSY ATTN ARMY ATTACHE
1 NATL INST FOR ALCOHOL RES OSLO
2 FRENCH LIAISON OFCR ARMY AVN TEST BD FT RUCKER
1 BRITISH LIAISON OFCR ARMY AVN TEST BD FT RUCKER
1 AUSTRALIAN EMBSY OFC OF AIR ATTACHE WASHINGTON ATTN T A NAVGN SQDN LDR
1 YORK U DEPT OF PSYCHOL
2 AUSTRALIAN EMBSY OFC OF MILIT ATTACHE WASHINGTON
1 U OF SHEFFIELD DEPT OF PSYCHOL
1 MENNINGER FOUNDATION TOPEKA
2 AMER INST FOR RES WASHINGTON
1 AMER INST FOR RES PGH ATTN LIBN
1 COLUMBIA U SCH OF BUS
3 MATRIX CORP ARLINGTON ATTN TECH LIBN
1 AMER TEL+TEL CO NY
1 U OF GEORGIA DEPT OF PSYCHOL
1 OBERLIN COLL DEPT OF PSYCHOL
1 GEN ELECTRIC CO SANTA BARBARA ATTN LIB
1 VITRO LABS SILVER SPRING MD ATTN LIBN
1 U OF GEORGIA DEPT OF PSYCHOL
1 U OF UTAH DEPT OF PSYCHOL
1 AMER INST FOR RES LOS ANGELES
1 AMER INST FOR RES PALO ALTO CALIF
1 MICH STATE U COLL OF SOC SCI
1 N MEX STATE U
1 ROWLAND + CO HADDONFIELD NJ ATTN PRES
1 NORTRONICS DIV OF NORTHROP CORP ANAHEIM CALIF
1 LING TEMCO VOUGHT INC WARREN MICH ATTN HEAD HUMAN FACTORS
2 AIRCRAFT ARMAMENTS INC COCKEYSVILLE MD
1 AMER MACH + FOUNDRY CO GREENWICH ENGNR DIV STAMFORD CONN
2 OREGON STATE U DEPT OF MILIT SCI ATTN ADJ
1 TUFTS U HUMAN ENGNR INFO + ANLS PROJ
1 AMER PSYCHOL ASSOC WASHINGTON ATTN PSYCHOL ABSTR
1 NO ILL U HEAD DEPT OF PSYCHOL
1 GEORGIA INST OF TECH DIR SCH OF PSYCHOL
1 OHIO STATE U DEPT OF AVN
1 REPUBLIC AVN CORP FARMINGDALE LONG ISL ATTN SUPERV ENGNR LIB
1 LIFE SCI INC FT WORTH ATTN PRES
1 AMER BEHAV SCI NY
1 INTERNATL INVENTORS CONGRESS CHICAGO
2 DIR INSTR RESOURCES STATE COLL ST CLOUD MINN
1 COLL OF WM + MARY SCH OF EDUC
1 SO ILLINOIS U DEPT OF PSYCHOL
2 HOWARD RES CORP ARLINGTON
1 NORTHWESTERN U DEPT OF INDSTR ENGNR
1 NY STATE EDUC DEPT ABSTRACT EDITOR AVCR
1 CHF PROCESSING DIV DUKE U LIB
1 U OF CALIF GEN LIB DOCU DEPT
1 FLORIDA STATE U LIB GIFTS + EXCH
1 HARVARD U PSYCHOL LABS LIB
1 U OF ILL LIB SER DEPT
2 U OF KANSAS LIB PERIODICAL DEPT
1 U OF NEBRASKA LIBS ACQ DEPT
1 OHIO STATE U LIBS GIFT + EXCH DIV
1 PENNA STATE U PATTEE LIB DOCU DESK
1 PURDUE U LIBS PERIODICALS CHECKING FILES
1 STANFORD U LIBS DOCU LIB
1 LIBN U OF TEXAS
1 SYRACUSE U LIB SER DIV
1 U OF MINNESOTA LIB
1 STATE U OF IOWA LIBS SER ACQ
1 NO CAROLINA STATE COLL DH HILL LIB
2 BOSTON U LIBS ACQ DIV
1 U OF MICH LIBS SER DIV
1 BROWN U LIB
2 COLUMBIA U LIBS DOCU ACQ
1 DIR JOINT U LIBS NASHVILLE
1 U OF DENVER MARY REED LIB
2 DIR U LIB GEO WASHINGTON U
2 LIB OF CONGRESS CHF OF EXCH + GIFT DIV
1 U OF PGH DOCU LIBN
1 OFC OF DIR CATHOLIC U LIB ATTN PSYCHOL DEPT LIB
1 U OF KY MARGARET I KING LIB
1 SO ILL U ATTN LIBN SER DEPT
1 KANSAS STATE U FARRELL LIB
1 BRIGHAM YOUNG U LIB SER SECT

AD________________________Div. 6, 16, 22

Human Resources Research Office, George Washington U., Alexandria, Va. 22314
THE EFFECTS OF OBSERVER LOCATION AND VIEWING METHOD ON TARGET DETECTION WITH THE 18-INCH TANK-MOUNTED SEARCHLIGHT, by Nicholas B. Louis, June 64, 52 pp. incl. illus, tables, 12 refs. (Technical Report 91)
(Contract DA 44-188-ARO-2) (DA Proj 2J024701A712) Unclassified Report

An experiment was designed to determine the effects on target detection of observer location and method of viewing in relation to several types of targets at selected distances. Data were collected from 336 observers stationed at the searchlight source and at various distances up to 160 yards from the light, along a line at approximately a right angle to the axis of the beam. Using the tank range finder, periscope, binoculars, or unaided vision, observers tried to detect and identify a jeep, tank, and APC at each of four distances. Observers farther away from the light source detected and identified more targets than observers close to the searchlight. Binoculars and, for the first 30 seconds, unaided vision were more effective than the range finder or periscope in detecting and identifying targets.

UNCLASSIFIED

1. Detection and tracking—target discrimination
2. Lighting equipment—searchlights
3. Vehicles—armored vehicles

I. Title: ARMORNITE V
II. Louis, Nicholas B.
III. U.S. Army Armor Human Research Unit, Fort Knox, Ky.
IV. Contract DA 44-188-ARO-2

AD________________________Div. 6, 16, 22

Human Resources Research Office, George Washington U., Alexandria, Va. 22314
THE EFFECTS OF OBSERVER LOCATION AND VIEWING METHOD ON TARGET DETECTION WITH THE 18-INCH TANK-MOUNTED SEARCHLIGHT, by Nicholas B. Louis, June 64, 52 pp. incl. illus, tables, 12 refs. (Technical Report 91)
(Contract DA 44-188-ARO-2) (DA Proj 2J024701A712) Unclassified Report

An experiment was designed to determine the effects on target detection of observer location and method of viewing in relation to several types of targets at selected distances. Data were collected from 336 observers stationed at the searchlight source and at various distances up to 160 yards from the light, along a line at approximately a right angle to the axis of the beam. Using the tank range finder, periscope, binoculars, or unaided vision, observers tried to detect and identify a jeep, tank, and APC at each of four distances. Observers farther away from the light source detected and identified more targets than observers close to the searchlight. Binoculars and, for the first 30 seconds, unaided vision were more effective than the range finder or periscope in detecting and identifying targets.

UNCLASSIFIED

1. Detection and tracking—target discrimination
2. Lighting equipment—searchlights
3. Vehicles—armored vehicles

I. Title: ARMORNITE V
II. Louis, Nicholas B.
III. U.S. Army Armor Human Research Unit, Fort Knox, Ky.
IV. Contract DA 44-188-ARO-2

AD________________________Div. 6, 16, 22

Human Resources Research Office, George Washington U., Alexandria, Va. 22314
THE EFFECTS OF OBSERVER LOCATION AND VIEWING METHOD ON TARGET DETECTION WITH THE 18-INCH TANK-MOUNTED SEARCHLIGHT, by Nicholas B. Louis, June 64, 52 pp. incl. illus, tables, 12 refs. (Technical Report 91)
(Contract DA 44-188-ARO-2) (DA Proj 2J024701A712) Unclassified Report

An experiment was designed to determine the effects on target detection of observer location and method of viewing in relation to several types of targets at selected distances. Data were collected from 336 observers stationed at the searchlight source and at various distances up to 160 yards from the light, along a line at approximately a right angle to the axis of the beam. Using the tank range finder, periscope, binoculars, or unaided vision, observers tried to detect and identify a jeep, tank, and APC at each of four distances. Observers farther away from the light source detected and identified more targets than observers close to the searchlight. Binoculars and, for the first 30 seconds, unaided vision were more effective than the range finder or periscope in detecting and identifying targets.

UNCLASSIFIED

1. Detection and tracking—target discrimination
2. Lighting equipment—searchlights
3. Vehicles—armored vehicles

I. Title: ARMORNITE V
II. Louis, Nicholas B.
III. U.S. Army Armor Human Research Unit, Fort Knox, Ky.
IV. Contract DA 44-188-ARO-2

AD________________________Div. 6, 16, 22

Human Resources Research Office, George Washington U., Alexandria, Va. 22314
THE EFFECTS OF OBSERVER LOCATION AND VIEWING METHOD ON TARGET DETECTION WITH THE 18-INCH TANK-MOUNTED SEARCHLIGHT, by Nicholas B. Louis, June 64, 52 pp. incl. illus, tables, 12 refs. (Technical Report 91)
(Contract DA 44-188-ARO-2) (DA Proj 2J024701A712) Unclassified Report

An experiment was designed to determine the effects on target detection of observer location and method of viewing in relation to several types of targets at selected distances. Data were collected from 336 observers stationed at the searchlight source and at various distances up to 160 yards from the light, along a line at approximately a right angle to the axis of the beam. Using the tank range finder, periscope, binoculars, or unaided vision, observers tried to detect and identify a jeep, tank, and APC at each of four distances. Observers farther away from the light source detected and identified more targets than observers close to the searchlight. Binoculars and, for the first 30 seconds, unaided vision were more effective than the range finder or periscope in detecting and identifying targets.

UNCLASSIFIED

1. Detection and tracking—target discrimination
2. Lighting equipment—searchlights
3. Vehicles—armored vehicles

I. Title: ARMORNITE V
II. Louis, Nicholas B.
III. U.S. Army Armor Human Research Unit, Fort Knox, Ky.
IV. Contract DA 44-188-ARO-2